Surgical Philosophy in Mass Casualty Management WITH DETAILED NOTES ON PRACTICAL CARE

By

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FOREWORD

This book is the natural outgrowth of our rather extensive experience in discussing the management of mass casualties before many audiences large and small, civilian and military, professional and lay Colonel Hughes participated in the original course in Management of Mass Casualties given at Walter Reed Army Medical Center in January of 1954, and he gave several of the lectures from that time forward. I was selected as a Student Discussor at this first course, later helped plan the course given periodically at Brooke Army Medical Center and gave several of the lectures in each course given there until being assigned to Tripler U S Army Hospital in September of 1956 When Colonel Hughes joined me at Tripler, we pooled our efforts and under the auspices of the Territorial Civil Defense Agency and Dr Richard K. C. Lee in particular we have put on a symposium five times on the island of Oahu and once each on the island of Maui, Kauai and Hawaii. The response to these meetings as well as to those where we have spoken to civil defense groups in various states on the Mainland seems to indicate sufficient interest to warrant this publication.

It should be distinctly understood that we speak only for ourselves and do not necessarily represent the thoughts or policies of the Department of Defense or any other agency of government. We acknowledge the influence, both positive and negative, of the many other speakers with whom we have shared the platform but have formed our own opinions, have crystallized our

thoughts and have thought through the problem to what we feel is a logical conclusion. Time may prove us wrong but we accept responsibility for the ideas expressed. An old Cheyenne Chief is reported to have said that it is better to have less thunder in the mouth and more lightning in the hand. At the present time when all anyone can do is urge and advise, we are full of the thunder of words with none of the lightning of action. It is our fervent hope that nothing more than thunder will develop but if a storm should arise, we sincerely hope that everyone will know what to do and how to do it. If we have assisted in this the book will have served its purpose.

We are indebted to all those whose ideas we have assimilated, to Mrs. Harriet Nakamitsu who has typed all the correspondence and the manuscript and to Mr Charles C Thomas who saw the advisability of this publication.

WARNER F BOWERS
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Surgical Philosophy in Mass Casualty Management

I

INTRODUCTION

Many difficult problems beset those who try to discuss the treatment of mass casualties Not the least of these difficulties is the fact that there are no experts to whom we may turn because no one has had actual experience in dealing with the mass casualties of a nuclear disaster For this reason it is easy for false prophets to arise and propound all manner of confused and confusing statements as to what will happen and what should be done. There has been a disturbing tendency for scientists to speak for publication concerning matters entirely removed from their field of knowledge and competence with the result that fears and anxieties are compounded needlessly It seems sensible to us to rely on combat experience and on rationalizations from civilian disasters, realizing that since we have halved the mortality rate of the wounded in action during each war since the Crimean War, surgery of trauma must be on a sound basis As long as human flesh and organs remain in their current type of structure and show the usual reactions to injury, we cannot expect new and different types of injury for treatment. This means that injuries will be the same old types with which we are familiar and with which we have had such good results in the past. The only new factor added is the element of time and even this is not absolutely new because in battle casualty work, many times there are more casualties than can be encompassed immediately In mass casualty situations, the extremely large number of wounded individuals must be cared for by a decreased number of trained per-

sons with limited supplies. This means therefore, that our main problem is to modify treatment so that meagre facili ties may be made available to as many casualties as possible, using our resources in the case groups where the best return can be realized. This, also is not new to military surgeons who are accustomed to working under adverse physical circumstances, often with insufficient facilities It has been stated that military surgery attempts to do the most good for the greatest number at the right time and in the proper place. This applies to surgery for mass casualties with the added stricture that needs will be greater and available resources more scanty The military surgeon attempts to maintain and preserve to the fullest extent all of the accepted principles of surgical policy and procedure, treating all casualties correctly and with good judgment even under the restrictions of military necessity These same principles pertain in a mass casualty situation except that we must abandon such concepts as "maximum care " "university hospital standards" and the thought that frills and niceties can be preserved. Our thought must be to save as many lives and limbs as possible with the facilities available, doing enough but nothing more than the bare minimum needed to accomplish the desired result.

We must be extremely careful to avoid the attitude that nothing can be accomplished and, therefore, nothing need be attempted. Contemplation of the case load of a million casualties is so unrealistic that we need not face this impossible hurdle. Never will there be enough litters bearers ambulances roads and space to amass such a case load in the first place and to ask doctors to make plans for such an artificial situation invites the philosophy of defeat. No big problem ever is solved at once in its entirety but we attack segments of the problem until the whole is encompassed. In like manner we can treat

ality, recognize the problem, make flexible plans and base concepts of treatment on current basic surgical principles. Subsequent developments may make necessary some modification but no drastic changes in fundamentals. Major General William F Dean has said that self-pity whips more people than anything else and Carlyle said that our main business is not to see what lies dimly at a distance but to do what lies clearly at hand.

In this book we propose to show that the situation will indeed be grim but that proper assessment of the situation, prior planning, utilization of a pre-formed organization, using short-cuts and modifications in accepted treatment, will allow a faint ray of hope in place of the gloom of total defeat.

II

COMMON SENSE RECOGNITION OF THE PROBLEM

Our rationalizations from combat surgery and analogies from civilian disasters may or may be valid but they are more apt to be correct than many of the naive, emotional and academic statements seen in print from various sources Blunt speaking is unavoidable in a subject as complicated and potentially serious as that of surgery for mass casualties where it is especially necessary to define our terms speak as accurately as possible avoid emotionalism, calm the evangelists, reassure the defeatists, silence the crackpots stir up interest in the lethargic, and do all in our power to arrive at a proper estimate of the probable situation to the end that we may make adequate, flexible, sensible plans on such a basis It must be emphasized again and again that the basic principles of management for cases of traumatic injury have been proven over and over These principles may be modified somewhat to meet existing circumstances but will not change radically All of our effort must be based on an accurate appraisal of the situation, current inventory of the personnel and materiel available followed by proper sorting of the casualties Our accomplishments will be directly related to the number of casualties requiring care as compared to our capabilities from the standpoint of trained personnel, supplies and time. Unless we arrive at a common sense recognition of the scope of the problem we may plan inadequately,

train improperly, organize poorly and waste personnel, supplies and time a matter of almost criminal negligence. Let us begin then by exploring some of the philosophies expressed in recognizing the problem

Do-Nothing School

Fortunately within the memory of living men no war has been fought on our home soil and such wars as there have been before that were largely rifle fire engagements with a few cannon of such low velocity that one could watch the missile approaching and duck at the appropriate moment. Since our shores have not been invaded and we have carried the war to the enemy it is alleged that this state of affairs will continue and that home destruction need not be feared. Consequently no planning or training is needed. This is a completely incomprehensible attitude when we have millions of veterans who have seen destroyed cities in other lands and who know the potentiality of foreign powers to wreak havoc even with conventional detonations The really sad part of all defeatist philosophies is that they prevent thoughts of planning for lesser disasters At one extreme is the accident where one patient results and can be cared for by one doctor At the other extreme is the chaotic condition where everyone in the nation will be killed at one fell swoop. For the one we need not prepare and for the other we cannot prepare but in between are all the fires, floods tornadoes explosions earthquakes eruptions and other civil or military disasters which can be encompassed to greater or lesser degree. It is fruitless to talk of millions of casualties but rather than frustrating ourselves by discussing the impossible, let us prepare for the largest disaster that we can handle and then do our best with whatever situation arises

Ostrich School

It has been said that thermonuclear warfare is too horrible an eventuality to contemplate and that like the chemical agents no one will dare use these weapons for fear of massive retaliation The case load is looked upon as being astronomical in numbers so that no plans could be made anyway Furthermore, it is alleged that every one within several hundred square miles will be killed outright so that there will not be any living casualties to treat. To cap this climax, it is stated that many targets will be struck at once with such overlapping areas of destruction that there will be no one alive to treat casual ties if they exist. All these statements may be idle theorizing or they may all be true. We know that gas war fare could wipe out whole populations but still we train against gas attack and still make gas masks. We theorize that our house will not burn to the ground or be bur glarized or that we will not fall dead tomorrow but still we buy insurance. It is all very well to believe that nothing will happen but Worchester tornadoes Lake Charles floods and Texas City explosions still occur Such dis asters take the same planning as thermonuclear warfare the difference being only one of magnitude All of our effort in training may be like insurance which never pays off but all mature men recognize the need for such in surance.

Take-in-Stride Philosophy

It might be assumed that doctors would recognize the problem from the nature of their training but this distinctly is not the case and from doctors we meet some of the most disturbing and insidiously dangerous phil osophy It often is said that we can handle the problem when it arises because we are used to treating cases of

trauma day in and day out. This statement, which is so tragic, is heard often by those who try to get something accomplished in the way of civil defense. For many years the American College of Surgeons has recognized that trauma cases in general, are poorly handled and it has been a common saying that it is safer to be wounded in battle than on the streets of one of our large cities. The Committee on Fractures of the American College of Surgeons was revised and enlarged to become the Committee on Trauma in recognition that increased em phasis was needed on treatment of trauma in general. If it is true that practitioners handle individual cases poorly, what will they do when confronted by tens, hundreds and thousands of cases? Even doctors with previous military experience function poorly in a civilian disaster of such small proportions as fifteen hundred injured. This par ticular disaster was extensively analyzed and will be discussed under a subsequent heading but at this point it can be said that the resulting fiasco indicates clearly what can happen when there is no prior planning, no coor dinated direction of effort and no adherence to well known surgical principles. When doctors put their knowledge of treatment of trauma on the shelf with their discarded military uniforms results show that those who say that civilian doctors can take a disaster in stride often are indeed ignorant of fact.

Naive Group

The "facts of life" often are unpleasant and those who never learn them make refreshingly naive comments which add a little grim humor In the numerous planning meetings before the finally approved list of supplies for 1 000 casualties was adopted, it was seriously proposed that we need not stockpile such a commonplace

item as penicillin because anyone knows that this can be purchased in every drugstore It should be needless to point out that the drugstore may be demolished and and at best its stock is small Again, it was argued that no suture material need be provided because cotton thread from the nearest dime store would suffice This slipshod thinking was shown for what it is by the discovery that without stockpiling, there would not be enough Tetanus toxoid in the entire country to give even a stimulating dose to each expected casualty Another concept which probably is naive is that which anticipates doctors, nurses and supplies materializing from surrounding villages in case of disaster to the large city Such a concept will work only with much prior planning and training At the risk of criticizing national policy, it should be pointed out that the jump-in the-car and head for the-country philosophy is naive. It should be realized by planners that we have an almost completely undisciplined population with an astounding lack of intelligence and regard for the rights of others Every fire is surrounded by curiosity seekers and every accident is cluttered by so many cars of onlookers that ambulances cannot approach the injured. People rush to the beaches to watch the tidal wave and if a tragic example of such lack of awareness is needed, the Texas City disaster is a good case in point. Here the schools were dismissed after the first explosion so that the teachers could lead the children to the waterfront to view the display Just as the docks become lined by teachers and children, the second explosion occurred, resulting in a high loss of life among individuals who had no business being within miles of the waterfront. The least attempt at realistic thinking about mass evacuation will show that a football game traffic snarl is a good example of what will

happen Mother will insist on driving north to pick up little Mary at school instead of going east as directed. Father will lock bumpers or fenders with some other courteous driver while onlookers honk their horns. Someone will run out of gasoline, another will have a flat tire and someone else will stall the motor Mass evacuation requires a group of intelligent, trained drivers which we simply do not have. Even if the evacuation went smoothly it has been said somewhat facetiously that if everyone in San Francisco jumped in the car as directed, 72 hours later the first car of the procession would be entering Salt Lake City as the last car was crossing the bay bridge. As a final thought, there is no point in mad flight by car without known destination and without some provision for food, gasoline and other facilities at the other end. Recent talk of tremendous areas of damage by fall-out should effectually dispose of mass evacuation unless all citizens are to be provided with jet propulsion.

Academic School

We have become so enamored of the idea that every one is entitled to the highest degree of free medical care and that even this really is not good enough, that any one who speaks of a more austere program is regarded as selling the American people short! We know that in most disasters secondary fires create a large number of burn casualties and we believe that in a mass casualty situation burns will make up as much as 25 per cent of the load. All doctors and nurses know that even a few burn cases can totally disrupt the best hospital because they take so much time and materiel for their immediate care. Yet, at national meetings we still hear the statement that in a disaster situation each burn patient should have serum potassium determinations, individually cal

culated diets to provide sufficient calories and accessory items such as vitamins that all cases are to be treated by the massive occlusive dressings and are to receive various routine injections of antibiotics just as we do for individual cases in a teaching center The stumbling block is the concept of "maximum" care as contrasted with "adequate" "minimum essential," or "austere" care It is all very well to plan for maximum care but this may lead to criminal waste of time and materiel

The academic dreamers learned that helicopters functioned well in Korea for evacuation of patients and immediately it was seriously suggested that we abandon ambulances jeeps planes, trains and ships in favor of helicopters Circumstances may never again be as favorable for helicopters as they were in Korea and even so the evacuation of 100 000 casualities by helicopter is totally unrealistic when we realize that the largest available copter accommodates less than six patients There is not the remotest possibility that there ever would be even a fourth the number of helicopters available for the total load. Planning on helicopters for more than auxiliary assistance is futile Academic planners must remember further that existing hospitals always are full before a disaster occurs that most cities have up to a 40 per cent shortage of required hospital beds at best and that most hospitals are in urban areas where their destruction is to be anticipated. Further, most doctors offices are in downtown centers so that medical personnel, as well as facilities may well be seriously crippled at the outset.

Sheer Magnitude of the Case Load

Our most pressing problem is the injection of some realism and common sense into the discussions on mass

casualty management in order to dispel the erroneous concepts previously mentioned. One way to accomplish this is to show by the sheer magnitude of the case load that the business-as-usual, take-it in-stride, maximum-care-for-all, concepts are totally inadequate and dangerous After we demolish these ideas possibly a workable philosophy will emerge.

Hiroshima, with a population of about 300 000, when devastated by our smallest A-bomb sustained 70 000 deaths 15 000 missing and 80 000 to 100 000 injuries. People are quick to point out that this was in an untrained, unwarned population but we also have an untrained population and who can say that we will have sufficient warning? Furthermore, more modern weapons may inflict over 100 times the damage done at Hiroshima. For the sake of argument, we are safe in estimating that one individual per every three to ten of population will become a casualty For a city of 500,000 population, this would give a casualty load of 50 000 to 150 00 cases. Remember that this city will be up to 40 per cent short on needed hospital beds, that all of these hospital beds already will be filled and that the hospitals may well be destroyed or hopelessly contaminated. Remember further that while in a flood or fire the casualties develop and accumulate slowly in a mass casualty situation the case load is engendered almost at once except for the results of secondary fires The saving factor is that casualties will be picked up and evacuated slowly so that the entire impact will not be immediate. Suppose we look first at the personnel aspect of the situation. On the average, one surgical operating team will take care of fifteen casualties in 24 hours but for the sake of discussion let us assume that the team will complete a case every hour This means that for the minimum figure of 50 000 cas-

ualties, over 2,000 surgeons are needed to say nothing of anesthetists, nurses and attendants From experience we know that all operative cases will never come to the operating room in the first 24 hours but if we spread the load over 48 hours, we still need 1,000 surgeons

It is obvious immediately that we will by no means have such a group of surgeons available and it is equally obvious, therefore, that we must change our planning to meet this situation Later discussion will bring out some alternate methods which appear to be acceptable substitutes. A serious difficulty is the matter of supplies because doctors are not used to being economical of equipment. With great difficulty a few years ago a minimal list of supplies needed to care for 1,000 mixed casualties for a 72-hour period was drawn up and this list has been fairly well agreed upon. However, in a mass casualty situation logistical problems will be almost, if not completely, insurmountable. For travel over paved roads, this list of supplies for 1 000 casualties can be loaded into two 2½-ton trucks for unpaved roads four such trucks are needed, and if to travel over open terrain six trucks are required. For the minimum load of 50 000 casualties therefore, it would require 100 to 300 truck loads of supplies This means a staggering amount of loading unloading, gasoline consumption and other logistical factors Difficult as this sounds, the burn cases will completely disrupt any thought of "treatment as usual"

It is estimated that at least 25 per cent of the casualties will have a 20 per cent to 30 per cent body surface burn and for 1,000 burns of 30 per cent, treated by occlusive dressings and with optimal fluids furnished, it takes 5 712 pounds of dressings occupying 890 4 cubic feet plus 42,066.5 pounds of fluids occupying 15,281.3 cubic feet. Figures for 20 per cent burns are not significantly

which is entirely familiar to military men but is unfamiliar and even repugnant to civilians who proudly rebel at "regimentation" or interference with their "freedom of action" Without organization in the event of disaster our citizens will be free to die and that is about all In Hiroshima because there was no organized first aid or rescue work, practically every injured person who could not walk out under his own power burned to death in the secondary fire storm The doctor is not responsible until the patient reaches him and it is in this initial period that avoidable deaths occur In Korea the mortality rate for battle casualties who lived to reach the first military installation (WIA) was reduced to less than 3 per cent which indicates that medical treatment has reached an exceedingly high order of excellence However, the death rate prior to reaching the first medical installation (KIA) has remained remarkably constant each war at about 25 per cent. This means that our greatest effort needs to be in organizing to pick up and evacuate casualties earlier Most of such activity is subprofessional, paramedical or whatever other polite phrase is designated for the necessary functions before the doctor begins to work. These functions will not be performed unless there is a pre-formed plan and unless every element of the plan is covered by a vigorous training program As will be mentioned later all attempts to test medical plans for management of mass casualties have shown the greatest weakness to be in communications, function ing of litter bearers and delivery of supplies, all subprofessional in scope but each capable of vitiating the best medical plans Doctors have a right to require two things, first, that other groups in the total plan organize and carry out their jobs to the best of their ability so that proper medical support is rendered and second,

cerely hoped that civilian groups will copy military organization for use in the event of mass casualties because what the Armed Forces dread most is the possibility that Martial Law might be declared, dropping a chaotic situation in their laps, without prior plans or training. The necessary organization does not spring up like the Minute Men without advance planning.

Considerable emphasis has been laid on urging every hospital to formulate an Emergency Plan but this is not enough. There must be a clear-cut plan of cooperation and coordination between the various hospitals in the area because previous civil disasters have shown that some hospitals are overrun while others remain almost unused. In urgent situations individual and group egos must be subordinated to an over-all plan for the general good. This is especially difficult because it is repugnant and because no one has the authority to plan or enforce it.

Training

Organization can be made entirely a paper transaction with accumulation of impressive charts and directives for filing away On the other hand, training implies a student group and, therefore, requires active participation of people. This is the point of difficulty because interest in civil defense always has been at a low ebb among the populace and no one has any authority to require compliance or attendance at training sessions. The training program must be a very extensive one covering all of the functions and skills listed in the previous section on organization. Every individual in the community should become proficient in at least one of these fields and in addition, every individual should be qualified in first aid, the elementary techniques of rescue and

survival and the basic principles of fire fighting First aid and self help training may be lifesaving in an emergency and this training should be pushed vigorously until every individual is qualified It is true that the Boy and Girl Scouts and the American Red Cross have shown interest in this field for many years but completion of a short course or the earning of a Merit Badge is not enough. All of us realize that knowledge or skills which are unused need periodic review if the material or ability is to remain in focus. It has been said that no abilities, however splendid, can command success without intense labor and preserving application This applies to training in first aid which should be repetitive and not a one-shot course. Furthermore, we do not use good judgment in first aid training. For many years we taught a very ineffectual method of artificial respiration to hundreds of giggling boy and girl scouts without anyone making much attempt at improvement. Finally, when a change was made, we had no more than gotten to the point where some people knew the name of the new system when we shifted to the mouth to-mouth technique which requires the use of a special piece of equipment. It can be depended upon that the apparatus will not be present at the same time and place as the casualty To hinge the whole effort on this piece of equipment seems to be poor judgment. Also such rapid changes seem like vascillation to the general public and foster even greater disinterest. Now we have abandoned the breathing tube and have advocated a true mouth to-mouth technique but this is most unesthetic and even repugnant so that a considerable "selling" job will be necessary

Another risky bit of teaching is the concept that doctors and nurses from other areas will come in and take over the treatment effort when a city is damaged. First, the

other city may need its own personnel and materiel and second, means of ingress may not be available. Teaching people to wait for help to come from a distance fosters the lap dog philosophy of yapping for someone to throw a bone rather than the bird dog philosophy of self reliance and foraging for oneself An inward orientation is better, stressing the need to make do rather than to call for help Naturally outside help is appreciated but the heart of the matter is expressed by Epicurus who said, "It is vain to ask of the gods what man is capable of supplying for himself" and by Hippocrates who said, "Prayer indeed is good but while calling on the gods, a man should himself lend a hand."

Too many times a training program talks "about" the subject, discussing the organization which should be formed, the training which should be given followed by a fire and brimstone presentation of how horrible the mass disaster will be. This is acceptable if this is followed by concrete common sense proposals as to what is to be done but too often we stop with the theoretical. We have aroused the people but have left them in midair Very often we bog down in personality clashes or jurisdictional disputes between the specialty groups. One petty but serious problem concerns who shall be "in charge" of the trauma case! Actually this question will not come up in a mass casualty situation because every one will be so busy that union rules will seem unimportant. As will be shown later many of the surgical specialties will have no particular place. This is because the vast bulk of the work will be soft tissue debridement which does not fit any particular specialty Chest cases usually do not require thoracotomy plastic surgery will not be done because most wounds will be debrided and left open, internal genitourinary wounds will be handled

as part of the abdominal wound if we operate upon these, eye wounds will be few and take low priority, nose and throat procedures will consist of debridement im mobilizing dressings and possibly tracheotomy, fractures will be treated as part of the soft tissue wound and in general there will be surgeons and neurosurgeons

Some medical plans genuflect to the various specialty groups by calling for the formation of definitive teams such as surgical orthopedic, maxillo-facial, shock, etc. similar to the teams of the Auxiliary Surgical Group of World War II It was found that these specialized teams were highly wasteful of personnel and most were un necessary We cannot afford to have idle specialist teams awaiting a case which fits within their field of special ization The only exception is the field of neurosurgery and in Korea special centers were established wherein neurosurgical teams were assigned Patients were assembled at these special centers by diagnosis Partly this is due to the fact that few surgeons other than neurosurgeons can or will do neurosurgery and partly it is due to the small case load which makes it more econom ical of people and supplies to concentrate them in few locations rather than many In a mass casualty situa tion we may let neurosurgical cases wait, as will be dis cussed later in which case only the basic surgical team is needed. In Korea we were able to use first and second year surgical residents to do casualty surgery and the excellent results attained by these relatively untrained men seemed to astound visiting consultants However the reason is simple Most battle casualty work is soft tissue debridement which the young man learns quickly The other and more complicated injuries are evacuated so that each surgeon actually needs to know only a few procedures More highly skilled men are assigned

as consultants to guide their juniors This system allows full utilization of partially trained men or men highly skilled in a special field which has low utilization. For example, a gynecologist quickly can learn wound debridement and will not be needed in his specialty A pedia trician should be adept at venipuncture and will be valuable in the pre and postoperative wards.

From what has just been said, it is apparent that doctors in junior years of training or in a specialty with no case load can quickly learn to do wound debridement with more mature consultation. Lt. Colonel H. H Ziper man at the Army Medical Service School pursued this point further and using wounded anesthetized goats, it was shown that professional men in allied fields or laymen who could face a wound without fainting could be super vised by a circulating consultant. The experienced sur gical consultant offered advice as to what tissue to ex ercise, what vessels to ligate, how much skin to remove, how long an incision to make, et cetera and was able to circulate between six surgical tables without difficulty This is one answer as to how doctors paramedical per sons and laymen can be utilized if an overwhelming case load is encountered. The extreme importance of this concept will become readily apparent subsequently

There is one other serious disadvantage to the preformed team concept and that is that the team is too rigid. In the holocaust of disaster the team members may be widely separated in space and it would be better to have the members basically qualified to do a number of things rathes than just one job This applies particularly to nurses, assistants and technicians who should be qualified in first aid, insertion of an intravenous needle, giv ing of a hypodermic injection sterile technique at the operating table, functions of a room circulator and pos-

sibly administration of drop ether under supervision Formation of rigid teams with clearly delineated skills may be too specialized for the needs and may be waste ful of personnel

Currently there is much talk that large groups of people should be taught how to do a tracheotomy This is not only entirely unsound but highly dangerous and brings up the point that we canot expect laymen to per form functions requiring surgical judgment In a sur vey at the Army Medical Service School Lt Colonel Zip erman found that few doctors had actually performed tracheotomy and relatively few were entirely sure of the indications. The do-it yourself instrument was found to be usable but did carry some danger It seems highly unlikely that we can expect people to carry the gas mask, the mouth to-mouth artificial respiration tube the syrette of atropine to combat nerve gas a container of blood plasma, a Thomas leg splint, a package of pressure dress ings, a tracheotomy tube and the do-it yourself tracheo tome! We know from past experience that not more than 1 per cent of battle casualties ever require a tracheo tomy and the wide upsurge of interest must stem from the data on the nerve gases If as predicted, these gases kill by respiratory drowning in secretions in a matter of minutes, it seems futile to expect the entire population to tracheotomize each other and inject each other with atropine. A simple check of the number of available tracheotomy tubes in the country will show the lack of realism of this plan.

Mention of the use of atropine brings up the test where enlisted men were instructed in the self use of a syrette and then were directed to administer the hypodermic injection to themselves Many completely lost their nerve and could not make the injection, others broke the syrette

in trying to prepare it for use many contaminated the needle which is not serious and the number who completed the injection was small. This result in a group of disciplined soldiers should indicate the type of performance to be expected from the population at large.

Even the use of a simple apparatus like the tourniquet has been a thorny problem requiring National Research Council advice on more than one occasion. Formerly, technicians were taught to apply the tourniquet to stop severe arterial bleeding and this is on the false assumption that a layman can distinguish between venous and artificial bleeding Next, the tourniquet almost never was applied properly and everyone who has ever worked in an emergency room knows that the first act should be to take off the tourniquet *so the wound will stop bleeding!* Then, it was taught that the tourniquet should be released briefly every 20 minutes in order to allow some blood to get into the extremity Thus, the patient, if the tourniquet really was needed, was allowed to exsanguinate slowly by increments each 20 minutes. This could be extremely serious in a six or eight hour litter haul. Later reasoning from the fact that orthopedists leave a tourniquet on the extremity at operation for up to three hours it was taught that release should be effected at about two-hour intervals. This still does not cover the unneeded application, the improper application and the increments of hemorrhage Finally it was realized that a good pressure dressing answers almost every need for a tourniquet and it now is taught that the pressure dressing is preferred. If a tourniquet is used, it should be with the idea that it is a physiological amputation which is to be completed later

In talking to paramedical groups, they always express the fear that they will be called on to do technical pro-

cedures requiring judgment which they do not possess We should reassure them in this regard and realize that medical judgment canot be expected of other than doctors To require more is grossly unfair

Utilization of Paramedical Personnel

Thus far we have played down the massive thermonuclear attack because this produces such an overwhelming case load of casualties that it encourages a feeling of hopelessness Therefore, we have emphasized the smaller civil disaster with hundreds or even thousands rather than millions of casualties Nonetheless, we must consider the larger problem so that at least some plans of action can be formulated Unclassified studies seem to indicate that with a multiple thermonuclear attack we might anticipate thirty to fifty million casualties, about half of whom would die within the first 24 hours. Unless we show great improvement in sheltering rescue, resuscitation, evacuation and medical care we expect a large per cent of the remaining casualties to be dead within 60 days. Thus it is apparent that doctors are not going to be able to cope with the problem Furthermore the medical problem is compounded when we remember that doctors nurses and other medical personnel are concentrated in a few hospitals or medical office buildings. These areas of concentration are apt to be in target zones so that losses of medical personnel may be at least twice as high in proportion to other categories of personnel. This loss is exceedingly serious because of the long training period needed to replace such persons Consequently we must think seriously of training other groups to substitute in as complete a manner as possible in medical care and management. This is foreign to peacetime concepts and there has been much

confusion as to first how far this substitution should go and as to what personnel are included. There is considerable difference in the capabilities and potentialities of the various paramedical groups inherent in their previous training and experience.

Of the various paramedical groups, the Veterinarians come closest to doctors of medicine by educational training and experience and consequently with some additional and refresher training, they have a wide range of usefulness Their duties in a mass casualty situation may well include the following

1 *First-aid and Resuscitation*
   a. Artificial respiration including establishment and maintenance of a patent airway by whatever means necessary including tracheotomy
   b Emergency lifesaving measures such as control of sucking wounds of the chest by occlusive dressing, control of hemorrhage by hemostat, ligature, pressure dressing or in extreme cases by application of tourniquet.
   c. Treatment of shock by intravenous administration of whole blood, fluids and/or plasma volume expanders
   d. Preparation of patients for movement by relief of pain by intravenous or hypodermic administration of narcotics or analgesics as directed and application of immobilizing bandages splints or casts
2 *Definitive Care of Patients*
   a. Intratracheal catheterization, administration of parenteral medications as directed and administration of local and/or general anesthetic agents under supervision.
   b Care of wounds to include control of hemorrhage,

suture of minor lacerations, debridement of major soft tissue wounds under supervision, secondary or delayed closure of wounds other minor surgical procedures assisting as a member of an operating surgical team and application of definitive dressings, splints and casts This includes care of burn patients

Pre and Postoperative Care

a. Insertion of nasogastric tubes, catheterization of male and female patients, and management of all suction and drainage tubes including thoracotomy tubes

Care of wounds, removal of sutures and drains, change of dressings administration of parenteral medications and immunizing agents as directed.

Public Health

a. Sanitation and waste disposal procedures to include examination of water, food and milk sources treatment to assure sterility and safety inspection of foods to include detection of radioactive contamination and supervision of proper method of distribution of water, food and milk supplies

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I *First-aid and Resuscitation*

a. All of the activities previously mentioned under the headings of artificial respiration emergency lifesaving, treatment of shock and preparation of patients for movement with a little closer supervision to aid his confidence and competence.

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b Care of wounds removal of sutures and drains change of dressings, administration of parenteral medications and immunizing agents as directed

4 *Public Health*

a. Sanitation and waste disposal procedures to include examination of water food and milk sources, treatment to assure sterility and safety inspection of foods to include detection of radioactive contamination and supervision of proper method of distribution of water, food and milk supplies

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The Dentist is more limited to a localized anatomical area in his training but his background is broad and he has close familiarity with technical apparatus anesthetic procedures and dealing with patients. In a mass casualty situation his duties might well include the following

1 *First-aid and Resuscitation*

a. All of the activities previously mentioned under the headings of artificial respiration, emergency lifesaving treatment of shock and preparation of patients for movement with a little closer supervision to aid his confidence and competence

b Triage of facial and oromaxillary cases when they have a high enough priority to come to surgery

2 *Definitive Care of Patients*

a All of the activities previously mentioned under the headings of anesthetic administration and wound care, plus added responsibility for oral surgery if trained in that aspect of dentistry

3 *Pre and Postoperative Care*

a. All of the activities previously mentioned under insertion and management of suction and drain age tubes and care of wounds with supervision.

The graduate Nurse, as traditionally is the case, is the doctor s good right hand and in general under mass casualty conditions her duties will be similar to those at present but with increased supervisory responsibility for groups of scantily trained ward attendants nurse aides, practical nurses or whatever term is applied to those who actually give bedside nursing care Operating room nurses can perform their usual duties may become members of the operating team or may do such procedures as debridement and delayed closure of wounds under supervision. Most nurses do not desire the responsibility for doing such procedures as tracheotomy and it seems unlikely that they need fear this eventuality However with supervision they may perform any of the functions allotted to the Dentist, plus the specialized functions nurses usually perform. Administrative and supervisory duties will be important where most of the jobs are being filled by persons who are somewhat outside of their usual sphere of knowledge and activity Uses of the Nurse are so broad that is is difficult to be more specific.

It seems fair to assume that some Laboratory X-ray and ward technicians as well as pharmacists may continue to perform their usual duties but if more urgently needed

elsewhere they may be called upon, along with dental laboratory technicians, dental hygienists and assistants, physical and occupational therapists, optometrists and other ancillary persons with manual skills and dexterity, to assume the duties of student nurses, ward attendants and surgical team members. Their help will be of the greatest value in assisting with resuscitation, definitive care and pre and postoperative care.

The Medical and Psychiatric Social Workers Clinical Psychologists, and Hospital Dietitians have had little contact with surgery of trauma or care of surgical patients but they may perform the duties of a student nurse in the wards or operating rooms with supervision.

The question of utilization of persons known to have received exposure to ionizing radiation always comes up and in the period of severe personnel shortage, such persons may be desperately needed to work within their capacities The early symptoms of whole body irradiation are nausea, vomiting diarrhea and malaise If these symptoms develop within the first eight hours the individual can be considered to have a fatal dose and cannot work. Some individuals may show these symptoms for psychogenic reasons so that a definite decision is difficult in the first 48 hours. Lesser doses of irradiation cause onset of symptoms later are of lesser severity and consequently recovery is quicker the later the onset. Late symptoms are infection, fever hemorrhage and anemia indicating that the height of the reaction has been reached, followed by slow recovery or death depending on original dosage Individuals may work in any of these stages provided that they are well motivated and if they are strong enough to be up and about. Those in charge should realize that no great harm is being done the individual and he might as well work as long as he is able The deciding factors are

dosage of irradiation, degree of training and motivation of the individual and the leadership skill of those in charge.

Chain of Command

History of civil disasters shows that usually an outside individual or agency has to come into the area and assume control before things begin to move. Partly this is because local disruption of organization paralyzes action and partly it is because there is no one locally who is recognized as the chosen leader Civilians always rebel at "regimentation" and being told what to do As a result, rarely can a local person get popular support. Individuals in military service know the need for teamwork and realize that qualified leadership is essential. Military rank is spoken of disparagingly by civilians but at least there is the advantage that there is a senior man who automatically is in charge. The chaos which attends an automobile accident is well known to all, order resulting when the policeman assumes control, the ambulance driver directs first-aid or rarely when some strong leader emerges from the crowd. The danger is that the strong leader who emerges may be a psychopath who has neither knowledge nor qualifications It would be much better if trained individuals could be identified in some way so that their assumption of control could be accepted. Trained individuals might well display the civil defense badges designating their special qualifications but at the moment such trained people are scarce. We pride ourselves on individual freedom of action but too often this is made the excuse for individual freedom to do nothing. Civil defense officials have no authority to do more than urge and advise and a look at their accomplishments indicates that their activities have influenced "things" more than "people " Paper organizations have been set up gen-

eralized plans have been formulated, teams have been designated and materiel has been stockpiled All this is good but "people" have not entered into the work as they should and there seems to be no way in which popular support can be achieved The disinclination to appoint qualified leaders and to follow them in a realistic training program may result in an extremely serious situation should emergency need arise.

Hospital Plans

It is well known that the simultaneous admission of 25 seriously injured or burned patients will very completely disrupt the orderly flow of events in almost any hospital in peacetime. This illustrates the fact that to handle casualties even in small numbers there are two basic requirements detailed prior planning and a well-oriented trained group of people to carry the plan into operation The plan must be as simple as possible so that the hospital can be reorganized quickly without too great loss of time and efficiency Also the plan must be flexible so that it can be modified quickly to accommodate unforeseen factors or greatly increased case loads Finally the plan must clearly define lines of authority and must set forth in detail the actual duties of the various individuals and classes of personnel In this regard it is very important to be sure that the plan does not require the same person to be in two different places simultaneously Job assignments must be realistic, economical and with due regard for maximum utilization of skills. It is well to make duty assignments by job title rather than by name of individual in a hospital where residents interns and staff change periodically Otherwise, the plan must be revamped, retyped and redistributed every few months to keep it current.

In preparing a hospital plan the first action is the ap-

pointment of a permanent Disaster Committee, usually with the Hospital Administrator or his Deputy as chairman. Committee members are from the professional services and from supply food service, pharmacy and ancillary services. The Disaster Committee has the following functions

1 It must set the stage by stating the problem and defining with what the plan is supposed to cope. For example the requirement may be to plan for the admission of up to 100 casualties in a two-hour period. This would take care of most urban civil disasters if each hospital had such a plan. In addition, there should be the requirement to take care of the hospitals proportionate share of casualties in case of thermonuclear attack.

2. It must develop the administrative and professional plan, coordinating all elements and resolving conflicts of space and personnel usage. The Disaster Committee will have two working subcommittees—Administrative and Professional, but the whole committee must coordinate the recommendations of the working groups.

3 It must coordinate the completed disaster plan with the plans of the other local hospitals and agencies concerned. This is extremely important if wasteful duplication or disastrous omission is to be avoided. For example if there is to be a central blood bank for the area, for each hospital to duplicate this effort would be wasteful but plans to take over in case the blood bank cannot function, must be made. Coordination should include plans for a central medical regulating officer to allocate hospital beds to prevent overloading of one hospital and non-use of another The importance of full inter hospital and inter

agency cooperation and coordination cannot be stressed too strongly This will be strikingly brought out in the section on lessons learned from civilian disasters.

4 The Committee should see that all persons concerned are oriented in the plan fully trained to meet their expanded responsibilities and to this end the Committee should plan supervise and conduct drills at suitable intervals to assure that everyone knows where to go and what to do Such drills are very difficult because simulation of disaster situations is almost impossible

5 The Committee must see that the hospital is ready to meet a disaster and must review the plan at least twice yearly to see that it is adequate accurate and current.

The Disaster Committee divides naturally into Administrative and Professional Subcommittees and they, with frequent coordination of thought and effort, start with the initial alert warning reviewing every succeeding step in admission and care of casualties Since there is much overlap of administrative and professional activity the following discussion will attempt to follow the chronology of planning, admission of patients patient care and disposition.

Utilization of currently available space and planning for physical plant expansion take first priority in the preplanning stage. Plans to use the current hospital building must be realistic, keeping in mind such obvious points as that a pediatric hospital has child-size beds and utility fixtures a psychiatric hospital will probably have scanty X ray and operating room facilities et cetera. Further if located in a target zone plans must call for total relocation if the building is too badly damaged or contaminated

to use. Plant expansion must envisage overflow into adjacent areas and buildings and must provide for total relocation to a larger site. In considering the original building or additional sites, there are a number of general considerations. First, normal hospitals are geared to handle few new patients at a time and frequently have poor or limited ambulance accesses. The private hospitals are apt to have multiple small rooms rather than wards, making care of large groups of patients difficult. Also internal traffic pattern often is poor for mass casualty work with operating rooms on the top floor necessitating a difficult litter carry if elevators are out of commission. In such cases it may be necessary to relocate the operating rooms in a basement or similar open area of more easy access and protection. In such cases or in planning a new site, careful attention must be given to internal traffic flow avoiding too many areas of jamming by cross-currents retracing of steps dead-end corridors, excessive steps and dependence on elevators. If possible the service areas—operating rooms X ray and laboratory—should be functionally located in regard to each other Adaptability of buildings will depend on what furniture and fixtures are normally present. An auditorium with fixed seats cannot be used for a triage area nor can an auditorium with sharply sloping floor A warehouse is apt to have too few light, water and sewer connections Need for a heating system must be considered, keeping in mind that an elaborate steam system may not be in working order and a system of space-heaters may be preferable. Accessibility is a factor not only from the standpoint of the road net but the ease with which emergency utility hook-ups can be made.

One of the greatest difficulties is in communication and probably all hospitals would be wise to adopt the pocket

radio system for calling doctors or sending out announcements. The telephone lines will be down or clogged by anxious relatives so that no plan should include dependence on telephonic communication Space may be available but still not economically usable as in the auditorium example. Multiple floor levels add difficulty, few access doors cause trouble many small rooms decrease efficient care and large barn like structures may be difficult to heat and may give a terrific problem with noise. Tentage requires a lot of open space but has the advantage of allowing planned arrangement Empty boxcars and trailer trucks have been investigated for use as operating rooms or as first aid stations and have distinct possibilities In tents or adapted buildings simple utilities like Lister bags for water small portable generators for electricity, makeshift or simple space-heaters and slit trenches for sanitary facilities allow rather rapid conversion to a usable hospital Even in normal hospital buildings plans must envisage alternatives for supply of heat light, water and sewer connections.

Mass feeding for patients and workers will be a problem Workers may be fed dry or pick up food like sandwiches or pieces of fruit which can be eaten on the job and without utensils. For patients paper plates or bowls may be stockpiled and a simple menu like stew or thick soup allows easy conversion to postoperative diet by crude straining or sieving.

Transportation problems divide themselves into external and internal varieties External transportation is out of the hands of the hospital but close liaison with policemen is essential because serious results have followed clogging of access and exit roads The ambulance turn-around area is no place for meddlesome visitors and parked vehicles Drastic action may be needed to maintain

order instead of letting chaos reign. Patients may arrive in all manner of conveyances and it is essential to prevent the driver from leaving his vehicle in the way while he helps a patient into the hospital. Internal transportation will be strained because the availability of litters and wheel chairs is limited at best. Plans should attempt to minimize need for transportation within the hospital. Traffic control is inseparable from transportation problems and externally police and volunteers will be in charge. Within the hospital definite traffic patterns must be established and signs with arrows should be prepared. These are useful at normal times but may be of a temporary variety for quick display pointing out routes to essential areas. Internal traffic direction may be required at areas of congestion

Communications have been mentioned as a most frequent area of breakdown and pocket radios have been advocated. In addition the hospital s normal page system may work and walking wounded may be used as runners to carry messages records and supplies The use of liberal quantities of signs is made even more necessary if such individuals who are unfamiliar with the building are to be used successfully

Planners must provide for a maintenance crew because all utilities will be overworked and abused so that failures will be more frequent than normally Such maintenance persons should have broad training not limited to unscrewing a light bulb Many basic decisions must be made before a disaster plan can be finalized. For example, will patients be undressed and changed to hospital garb such as pajamas? Probably it is best not to undress the patient because pajamas will become unavailable and thus two systems are needed—one for pajamas and one after they are used up Furthermore, undressing the patient takes

time may be impossible because of burns or wounds and adds the problem of care of valuables. On the other hand, if there is radioactive contamination we may have to go to the other extreme removing and discarding all clothing Triage of patients for immediate removal to a suitable ward should not be slowed by checking of clothing and valuables which in itself requires a crew of people, storage space and maintenance of records Leave the patient dressed and in possession of valuables until he reaches the ward Then change to pajamas if desired but keep clothing and valuables with the patient Actually, it would be easier to pilfer a central storage area than to search and rob individual patients Even in the operating room only localized exposure is essential and complete disrobing as normally done is not required keeping in mind only the requirements for adequate physical examination. Use of linens must be considered because laundry facilities may be disrupted. Since patients are not to be undressed, sheets will become very soiled immediately but cannot be changed for each patient. It may be decided to rinse out sheets wring as dry as possible and reuse them in a damp state. In the operating room draping will be at a minimum using towels almost exclusively and these can be rinsed out, boiled cooled wrung out and used damp Surgical gauze sponges can be treated similarly and re-used many times Most surgeons use moist sponges by preference anyway

When an alert is received, a very immediate problem concerns the disposition of patients who already fill the hospital beds The first duty of ward doctors, before casualties begin to pour in, is to make a quick ward inventory dividing patients into three groups, those who can be discharged immediately those who can be ambulatory but need care and the bed fast group On a surgical ward,

even the postoperative cases of the previous day can in general be considered ambulatory This certainly includes appendectomy herniorrhaphy thyroidectomy and lesser procedures On call from central authority the discharged patients are sent to the personnel pool at receiving office to act as guides, runners traffic control men or other jobs other than litter bearer Ambulatory patients should be sent to the walking wounded area, to some other designated spot such as an auditorium or may be kept on the ward to assist in minor ways Bed-fast patients should be congregated in one ward or may be left on their original ward if preferred. Discharged patients may not need transportation as they may have no place to go and, in addition, they may be needed as workers. Records should be simply stored and no other formality need be gone through. Re-issue of clothing and valuables to discharged patients is obviated if they continue to wear convalescent suits and remain to work. Plans must include later discharge of patients and evacuation of patients to other centers when that system becomes operational. When the ward doctor clears his ward, a report must go immediately to the Medical Regulating Officer (Registrar or other title) who is stationed at the triage point. This gives him an immediate census of empty available beds by ward. The clerk who accompanies the triage officer keeps a roster by patient name, short diagnosis and ward to which sent. The running census allows him to know where beds are available and the roster affords the public relations group information as to who has been admitted to what ward. Some system to keep the regulating officer periodically informed of bed status is necessary because other wise he will not know what beds are vacated on preopera tive wards by patients going to the operating room or on expectant wards by patient deaths Futhermore, a roster

must be kept in the operating room to show patient name, ward of origin operation performed surgeon's name and postoperative ward of destination This is the best way to correct the original admission roster which becomes incorrect as soon as a patient goes to the operating room

Advance planning must include many decisions and actions regarding hospital personnel For example all persons should have and wear an identification badge which at least gives the name and preferably the duty station Even in normal circumstances the use of name tags is good procedure. The use of colored tags to designate job assignment would help to locate litter bearers ward attendants mess attendants and other categories of personnel at a glance Another basic decision concerns what is to be done about obstetrical cases There will be the normal deliveries plus the premature labors and abortions brought on by the stress of the disaster If possible it seems best to leave a minimal number of persons on duty for this work letting the delivery rooms remain for their intended purpose The only other possibility would be to refuse admission to delivery cases but this probably will not be done Handling of the dead is another matter for advance decision Prompt removal of the dead from the hospital is essential and a large storage area may be required. Adequate tagging for subsequent identification is preferred but in difficult times immediate burial in mass graves with the aid of a bulldozer may be the only available answer Decision as to whether volunteers will be used must be made These volunteers may be relatives walking wounded, discharged patients or persons in other unemployed categories Personnel pools should be established in several areas from whence litter bearers can be drawn as needed. This is hard work and litter bearers have a human tendency to "goof off" as quickly as possible so

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gery and may feel insecure Such staff men may be assigned to ward work, may be used to assist senior staff surgeons or may be assigned as team chief with a second year surgical resident as a bolstering assistant. Tact and diplomacy are important in making team assignments to utilize skills adequately to maintain lines of union demarkation and to avoid fracturing sensitive egos The Chief of Surgery should not be put on a team because he is to function in the receiving area as triage officer He should have a third year surgical resident with him to render lifesaving care as will be mentioned later The Assistant Chief of Surgery should not be assigned to a team because he should be in charge in the operating room His duty is to circulate between the operating tables offering technical advice and possibly momentarily assisting in a difficult spot but he should not become immobilized at a table He is an expediter and consultant. As has been mentioned before and will be said again he can supervise up to six nonsurgeons as they debride wounds thus substituting individuals of lesser skills Basic debridement teams are the most essential and specialty teams are wasteful. One eye-maxillo-facial team might be kept busy and one or two neurosurgical teams might be profitable but as will be shown, these cases can wait without great loss and wound debridement most profitable. All persons in the hospital sho their job assignment the place to which they the event of an alert, to whom they are detail what constitutes their job T fr attendant to chief from ward ing plan Standard mooth work upon and taught l be agreed to be asking for no time Care must be the de-

a definite circuit should be established. For example, bearers may take a patient to the preoperative ward, pick up another patient ready for the operating room and there pick up a patient for delivery to the post operative area. At this point some system is needed to get the bearers back to the receiving area without slipping off A rest period in the pool area then is followed by another trip Bearers must not be allowed to congregate at way stations A pool of less vigorous persons can make up the guide and messenger pool and another pool for delivery of supplies may be needed. Other uses will occur to individual planners.

Every person in the hospital should be accounted for in the disaster plan job assignments and specific duties should be listed for each job with definite delineation of chain of command and extent of authority One immediate problem is that doctors often are staff members at several hospitals and obviously can serve on only one team at one hospital. Liaison with the County Medical Society is needed to allocate doctors to specific hospitals. Decision should be made as to how many operating tables can be utilized at one time, placing two or more tables in a large operating room, with one circulating nurse for the whole room, one scrub nurse to alternate between tables and one back table of sterile supplies for the whole room. The number of possible tables determines the number of operating teams required at first. There may be an anesthetist for each table or maybe one per room because anesthesia will be as simple as possible. The operating team is made up of surgeon and assistant. Fourth- and third year surgical residents can be team chiefs, with technicians, interns or junior residents as assistants. Also, it must be borne in mind that some staff doctors, such as the ophthalmologist, may not have done soft tissue sur

gery and may feel insecure Such staff men may be assigned to ward work, may be used to assist senior staff surgeons or may be assigned as team chief with a second year surgical resident as a bolstering assistant. Tact and diplomacy are important in making team assignments to utilize skills adequately, to maintain lines of union demarkation and to avoid fracturing sensitive egos The Chief of Surgery should not be put on a team because he is to function in the receiving area as triage officer He should have a third year surgical resident with him to render lifesaving care as will be mentioned later The Assistant Chief of Surgery should not be assigned to a team because he should be in charge in the operating rooms His duty is to circulate between the operating tables offering technical advice and possibly momentarily assisting in a difficult spot but he should not become immobilized at a table. He is an expediter and consultant. As has been mentioned before and will be said again he can supervise up to six nonsurgeons as they debride wounds thus substituting individuals of lesser skills Basic debridement teams are the most essential and specialty teams are wasteful. One eye-maxillo-facial team might be kept busy and one or two neurosurgical teams might be profitable but as will be shown these cases can wait without great loss and wound debridement is the most profitable All persons in the hospital should know their job assignment, the place to which they should report in the event of an alert, to whom they are responsible and in detail what constitutes their job Training for the specific job from ward attendant to chief surgeon is essential to a smooth working plan Standard operating procedures should be agreed upon and taught because a disaster situation is no time to be asking for special instruments and pet sutures

Care must be exercised in assigning members of the de-

partments other than surgery because they do not want to operate and yet they want a part in the show The Chief of Medicine should have charge of all the wards in a supervisory-administrative-professional-expediter position. Ward officers can be doctors from medical and specialty wards and services dental officers and veterinarians Oral surgeons can be on surgical teams pediatricians do well on pre and postoperative wards et cetera. If the disaster continues to develop a greater case load, more surgical teams are improvised and personnel move up to more responsible surgical jobs leaving ward work to lay persons under some supervision.

Advance pre-planning is needed regarding the reception and dissemination of the original alert message. This is extremely important but must not be allowed to immobilize important people. For example, the official who receives the alert should call a designated few key people, each of whom calls a designated group For one man to make all the calls would be interminable. Further when the Chief of Surgery is called he should not be immobilized at the phone alerting others but should proceed to his triage station. In other words, those whose duties will begin first, should not have to make a series of phone calls Also with the pyramidal system of calling, it must be realized that if one man is not alerted, all those below him in his pyramid fail to be notified also Special plans for day and night alerting are essential. This alerting of personnel is exceedingly important and also very difficult. Even in normal times many people fail to "get the word."

The final administrative matter for pre-planning refers to supply and issue system The supply officer should issue on phone or runner order without prepared requisitions or on hand receipt only He should have certain prepared lists so that for example when an additional ward is to

be opened he knows immediately what additional supplies are needed for that number of beds Previous usage factors are very helpful to the supply officer at this time. For the operating room, he knows that instruments and tables will be added only rarely and most requests will be for expendables like dressings and sutures The simplest possible system of supply and issue is best, delivery being made by runners from the personnel pool and supply personnel being saved to set up orders

The previous discussion now brings us to decisions and procedures directly concerned with patient care although the previous material has overlapped into this field. First, the walking wounded area should be established, presided over by someone skilled in first aid and bandaging plus police assistance. These patients must be kept from cluttering up the triage point and are available for such work as they can do The area should allow for expansion and should not encroach on the hospital access and exit area. Visitors will flock to the hospital and must at all costs be kept out of the triage area and from overrunning the hospital Firm police action here is essential. An information desk may be established here from whence rosters of hospital admission, et cetera, may be released by loud speaker or other means. Hysterical and mentally disturbed visitors and relatives may create a problem but no one should be allowed to interfere with patient care. Visitors and relatives who volunteer to work may be acceptable but this must not be an excuse to tag along with a friend or relative exclusively

The triage point or sorting area is the basic element in good treatment. Physically there must be room to arrange litters or patients in suitable long rows with aisles and spaces between. The Chief of Surgery accompanied by a third year surgical resident and possibly a first year man

plus a registrar clerk, goes quickly down the line. For each patient he makes a quick physical examination for location, number and degree of injuries. The clerk jots these on the tag as the surgeon talks The surgeon determines whether emergency care is needed in which case the first year man may put on a pressure dressing or the third-year man may stop to do a tracheotomy Intravenous fluids and hypodermic medications should not be given here. The surgeon decides quickly between the four categories—minimal injury immediate care, delayed care, expectant treatment—and decides on which ward is to receive the patient. The clerk notes category by Roman numeral, ward number and diagnosis on the tag for the patient. He or a second clerk adds the same data to the running roster A junior nurse or other person should precede the surgeon and aid in exposure of the wounded area. In this manner the surgeon can see a patient in about one minute, make the diagnosis, categorize the injury decide on the ward of admission, direct emergency treatment if needed and pass on. The clerk has the tag and roster up to date and litter bearers carry the patient away according to the established traffic pattern. In some instances the surgeon may remain in one spot as casualities are carried past him for the above decisions. He puts to one side those requiring emergency care. This is more extravagant of litter bearers however

From the triage point, patients are taken to the designated ward. Minimal injury cases may join the walking wounded, may go direct to minor surgery for wound dressing or may go to a preoperative ward. Immediate care patients go to a preoperative ward and thence to surgery as fast as operating teams can function. Delayed care patients go to a preoperative ward for resuscitation such as fluid or blood administration to prepare them and

then are sent to surgery Expectant care patients go to a designated area where they are given support and reevaluation If they improve revision to the operative group may be possible Patients should be concentrated on wards somewhat by diagnosis. An example is burn patients or neurosurgical cases On reaching the ward a ward roster is made from the patient s tag and the ward doctors see the patient as quickly as possible. Preoperative care will consist largely of fluid or blood administration plus some narcotic medication.

In the operating suite, the chief anesthetist is the expediter and should not be tied down to a table He should have charge of scheduling cases which consists merely of telling litter bearers to bring another patient. A patient should be outside each operating room door waiting because no setup will be needed between cases. Surgeons can wear rubber apron, cap, mask and gloves but need not gown. The operator can tell from the emergency tag which diagnosis has been made and what resuscitation has been given. Cases may be allocated somewhat by diagnosis to certain teams this being done by the chief anesthetist. The assistant chief of surgery meanwhile circulates between tables as mentioned earlier At conclusion of the operation, the procedure is recorded on the tag and a roster is kept to show the postoperative ward to which sent. Between cases the doctor should enter patient name, diagnosis and briefly what was done in the operative book from which more permanent records can be made later On the postoperative ward, any special operative orders are carried out but this will be mainly fluids as needed, narcotic for pain catheterize PRN and diet as tolerated.

Essentially this carries the patient from the receiving door through treatment and to the postoperative ward.

III
CHARACTERISTIC EFFECTS OF TRAUMA

Human tissues may be contused, abraded, lacerated, avulsed, macerated, burned by chemicals, electricity or heat, damaged by cold or immersion, disrupted by blast or cellularly injured by ionizing irradiation. How tissues will react to trauma depends on type and severity of injury body location elapsed time between injury and medical care and a host of more or less intangible factors. Most of these points are well understood, will not be essentially different in a mass casualty situation and will respond to the usual methods of therapy which have proven so successful in the past, provided that we have time trained personnel and supplies.

However certain factors which affect type and severity of injury must be emphasized for whatever preventive measures can be derived. It is obvious since flying objects, blast waves and the heat waves of flash burns travel in straight lines, that geographical features may make a marked difference in casualties sustained. The oft-quoted figures from the atomic bombing of Hiroshima and Nagasaki bear this out since Hiroshima is located in a flat terrain and Nagasaki is situated among ridges and valleys. The value of defilade is shown in the following chart.

ATOMIC BOMB CASUALTIES

	Hiroshima	*Nagasaki*
Deaths	70,000	45,000
Missing	15 000	2,000
Injured	80-100,000	30-60,000

Obviously other factors played a part but the protection of terrain was readily apparent in viewing the pattern of destruction

State of training and discipline of the population plays a definite role in end result and Japanese bombings again are cited, where there was an incidence of only 5 to 6 per cent of major fractures among the rescued casualties This was because there was no organized attempt at rescue and almost everyone who could not walk out under his own power burned to death in the rapidly ensuing fire storm Effectual rescue would have made marked differences in the type of casualties available for treatment. Also, individuals who look at the atomic flash may be blind for one to three hours so that even the uninjured may be incinerated because of inability to see to escape. It is thought that a young, disciplined military population would show fewer casualties than a mixed civilian group because of training and indoctrination. Urban casualties will depend on whether the disaster occurs in the day time when the downtown area is crowded with people at peak traffic periods when the roads are crowded or at night when most people are in the suburban areas Types of available shelter also will modify the picture. Prevailing weather will be important primarily because wind and fog will modify fall-out danger and season will have a direct bearing on exposure factors Finally type of clothing worn is important not only in exposure but because some fabrics melt readily at low temperatures and others because of dark color tend to absorb more heat rays The extensive use of plastics in clothing material may be harmful because these may melt, thus increasing the burns and augmenting the exposure subsequently

In a mass casualty situation it is estimated that Blast will account for 50 to 60 per cent of the injuries because

of the resulting flying foreign bodies. Thermal injuries will make up 30 to 35 per cent of the casualty group because of the original flash burns and the subsequent fire burns. Irradiation injury is estimated to make up 20 per cent of the group but this number may decrease with more potent weapons since fewer people will survive to show irradiation injury later That these figures total more than 100 per cent is anticipated because of the large number of combined wounds and multiple injuries.

Mechanical Injuries

Mechanical injuries will be caused by individuals being struck by displaced objects and flying glass or by themselves becoming flying objects dashed against immovable structures These wounds, then, will be by low velocity missiles as compared to the velocity of rifle bullets As General James Cooney has so pungently stated, if you are killed by a missile it really makes no difference whether it is a rifle bullet or a flying toilet seat, as far as you are concerned. However as far as treatment is concerned for the survivors it makes considerable difference as will be brought out in the discussion on wound ballistics because wounds from low velocity missiles require much less extensive debridement and the subsequent death of tissue which appeared grossly normal at debridement will be less Since there will be more flying missiles in an urban setting than in a rural area, it follows that the city disaster will show more mechanical injuries and more head injuries in particular

Blast Injuries

Although blast is listed as causing 50 to 60 per cent of the wounds in a disaster group actually this means mechanical wounds caused by displaced objects secondary to

blast or by translation of individuals who themselves become flying objects. Primary tissue damage from blast in air, per se will be limited almost entirely to a few ruptured eardrums The following figures indicate why blast is not a potent primary cause of tissue damage, psi standing for "pounds per square inch"

15 psi is the normal atmospheric pressure.
3 psi overpressure will damage a frame house
7.4 psi overpressure will crack a 12 inch thick brick wall.
25 psi overpressure will collapse reinforced concrete.
100 psi overpressure will kill a man.

Following World War II, many papers were written about the primary effect of blast and it is true that an occasional person will sustain rupture of pulmonary alveoli, death from pulmonary edema ensuing, but this is rare. This is because air is so highly compressible whereas blast in water is much more serious because water is not compressible and the full force is transmitted to the tissues.

Thermal Burns

Thermal burns may accompany and complicate 25 per cent of the casualties wounded by other mechanisms so that the treatment of burns will be a serious problem Flash burns occur as a result of direct transmission of heat to tissues by the heat wave which travels in straight lines. This accounts for the "profile" burn and the apparently impossible shielding by a leaf or blade of grass This type of burn is delivered by an instantaneous exposure in contrast to the flame burn sustained by direct contact with burning clothing or other objects Very small amounts of heat will damage tissue as is shown by the fact that delivery of two calories per square centimeter of body surface causes a first-degree burn (erythema like sunburn) three calories per square centimeter cause a second-degree burn (blistering) and eight

calories per square centimeter cause a third-degree burn (full thickness destruction of skin) Ten calories per square centimeter will burn through the military uniform. Although the temperature at ground zero in an atomic burst may reach 3 000 to 4,000 calories, the temperature decreases rapidly with the square of the distance so that at about 2.25 miles from epicenter, only a two-calorie sunburn is sustained. Naturally these figures vary with size and yield of the weapon. Since the flash burn is of a duration measured in tenths of a second, shielding is highly protective. This is shown by the protected area in the shadow of grass or leaves and by the protective area of light-colored patterns on darker cloth in clothing. These phenomena were seen at Hiroshima and have been described frequently

Although much has been made of the disfiguring scars in the burned patients who survived at Hiroshima and Nagasaki, these scars simply resulted from inadequately treated, infected full thickness burns which healed without skin grafting. There was no esoteric effect from the type of bombing itself These same end results may be anticipated in any disaster accompanied by fire, where wound infection is uncontrolled and healing is by secondary scarring.

Irradiation Injuries

Irradiation injuries may be of the immediate type or of the delayed variety depending somewhat on the dosage and on the time period. Prompt or immediate irradiation injury is most apt to occur in the area of maximal bomb damage (10 psi or greater) and therefore such individuals will, in addition, sustain severe or lethal injuries from heat or mechanical damage. Those farther away from the epicenter will have a greater tendency to

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survive but again are subject to combined type injuries so that pure irradiation injuries in the area of bomb damage will be almost, if not entirely, non-existent. On the other hand, fallout may cause immediate irradiation injury in persons otherwise unaffected by the disaster Delayed irradiation injuries result from continued exposure to low dosage over a period of time and this may be from working in a contaminated area or from being subjected to increments of fall-out. All of these factors vary with size and yield of the bomb as well as with other factors not pertinent herein

Irradiation injury is cellular in type and when once sustained, is irreversible until the full gamut of damage and repair has been run Unfortunately, although areas and materiel may be monitored to determine contamination, qualitatively and quantitatively, we cannot by any simple method measure the number of roentgens to which an individual casualty has been exposed. Actually, however since there is no specific therapy anyway this is an academic point and we await developments, treating as symptoms arise This means in essence that we must ignore irradiation injury when it comes to mass casualty treatment. Individuals who show irradiation symptoms in the first few days are doomed by present knowledge and those who require treatment for other injuries may subsequently die of irradiation but this we have no means of determining originally

Much has been made of the danger of irradiation injury but there is little real knowledge aside from theoretical considerations and semieducated conjectures. Unfortunately many scientists and pseudoscientists in all sorts of parallel fields have made national pronouncements regarding incidence of blood dyscrasias, genetic changes in the twenty-eighth generation and other matters which

catch lurid headlines. Much of the discussion is emotional and possibly ideological rather than factual. More profit accrues from discussion of matters which have some basis in knowledge.

Combined Injuries

From the foregoing discussions it will be seen that combined and multiple injures will be the rule rather than the exception. This is not unusual in battle casualty experience and the additional factor of possible irradiation injury need not be allowed to complicate the picture since, as has been indicated, we cannot assess the irradiation hazard at the time the other injuries require treatment. It is perfectly possible that we may spend hours repairing abdominal injury debriding wounds and splinting fractures only to have the patient die of late irradiation effects some weeks later At the moment this seems to be an unavoidable and unforeseeable eventuality and therefore we may as well not worry about it.

It is possible that hitherto rare or unknown combinations of injuries may be seen and one such lesion might be burns of eviscerated abdominal organs. Such combinations should be anticipated and plans for their management must be made. The main problem in combined injuries is one of deciding priority for treatment of the individual and deciding the order in which the injuries need care. This will be discussed elsewhere.

Wound Ballistics

Missiles produce their damaging effect by transmitting some or all of their kinetic energy to the tissues through which they pass. Since the kinetic energy of a missile is directly proportional to its velocity it follows that wounding power also is proportional to velocity As the missile

traverses tissue, the energy is expended in all directions so that a large temporary cavity is formed by the displacement of tissues This cavity is of micro-second duration and is something like thirty times the diameter of the tract which remains immediately after the missle has passed. Pressure in such a cavity often reaches 1,500 pounds per square inch and is sufficient to fracture bones even without actual contact with the missile itself For purposes of easy comparison it can be stated that a temporary wound cavity of baseball size leaves a residual tract of pencil diameter Missiles which remain in the tissues do so because they have expended all their energy, while those which pass through a part obviously have sufficient energy left to be able to continue on their path A soft fragmenting missile increases the wounding effect and fragments of bone may themselves become secondary missiles Ballistic shape of missiles influences their wounding effect since it is obvious that a missile which tumbles or wobbles in its path will produce greater tissue damage. Also, a jagged irregular fragment produces more local damage although since its velocity is apt to be less there is less distant damage from the explosive or cavitary effect. Hollow viscera may rupture secondary to abrupt changes in gas pressure in the lumen without actual perforation by the missile. Spongy viscera such as lung and hollow organs are damaged least by the temporary cavity phenomenon since air is so compressible Solid tissue such as muscle and liver or spleen behaves like a fluid system and is damaged most severly because of lack of compressibility Tissue viability is dependent upon an intact, adequate blood supply and tissue death following missile injury usually is due to impairment of blood supply rather than to direct damage to individual cells

Wound contamination in missile injuries is by three

distinct mechanisms. First, the "punching" action of the missile may carry foreign bodies into the depths of the wound. Second, the "splashing" action of the temporary cavity formation may spread foreign material widely in the tissues Third, the "sucking" action may draw material into the wound, even from the site of exit of the missile

Statistical studies to show what body regions are most frequently injured are of great importance in allowing us to plan on what types of injury will show the greatest case load. The results of such studies indicate that all is not hopeless in a mass disaster because fortunately the less severe and simpler wounds are by far the most frequent. The following table is a compilation of past experience in conventional warfare plus expected results from an atomic explosion in both urban and rural situations

	Atomic		*Conventional*
Body Area	*Rural*	*Urban*	
Head, Neck and Face	12%	35%	16%
Thorax	15	10	8
Abdomen	14	5	6
Upper Extremity	22)	(27	26)
	) 50 to 60%	(	) 70%
Lower Extremity	37) of total	(23	44)

This table shows that wounds of the extremities make up 50 to 70 per cent of the total case load and although the total implication of this will be discussed later it may be said here that obviously such wounds need debridement which is simpler and quicker than abdominal and neurosurgical cases Second, the end results are apt to be better as far as life is concerned and third, it is apparent that individuals of less training can do the bulk of the surgery whereas persons of much more training would be needed for such things as intestinal repair It will be shown further that the more severe cases can await definitive treatment with less loss than the soft tissue injuries.

All these factors mean that much can be accomplished in a disaster by relatively simple procedures

Postmortems on Battle Casualties

Experimentally, it can be shown that wounded anesthetized animals which die within the first 48 hours after injury, die of blood loss or asphyxia Further animals which survive for 48 hours have the potential to survive indefinitely except for the accepted mortality rate from such late effects as secondary blood loss and infection The prime problem then is blood loss and shock. In battle casualty work, we know that the KIA (killed in action) rate has remained essentially constant throughout the years at about 25 per cent, whereas the DOW (died of wounds) rate has been halved in each successive war A casualty who dies before reaching the first medical aid station is referred to as KIA while any wounded person who expires after having reached the first forward medical facility is said to die of wounds The individuals who sustain a direct injury to the heart are extremely few and essentially any individual KIA dies of blood loss The amount of blood loss needed to cause death varies widely with body area. A very minimal amount of blood lost into the subarachnoid space may cause death by central nervous system compression and a very small blood loss in the mediastinum may cause fatal tracheal or bronchial obstruction.

On the other hand, it takes only a moderate hemorrhage into the pericardial sac to kill by cardiac tamponade while a massive hemorrhage into the thoracic cavity is needed to kill by respiratory embarrassment. The peritoneal cavity can accommodate an almost totally exsanguinating blood accumulation as is the case with external hemorrhage. Blood loss into the neck kills early by re-

spiratory obstruction. Almost all battle casualties who are going to die, do so in the first 48 hours, usually before being picked up and usually of blood loss All these experimental and clinical observations confirm the impression that death is due to blood loss, that the type of injury determines the rapidity of hemorrhage or its compression effect, that most deaths in the first 48 hours are unavoidable because of inability to replace blood loss earlier and that most patients who survive 48 hours will do so indefinitely almost regardless of treatment received. These points should somewhat dispel the thought that medical therapy is definitive What we accomplish is more in the way of supporting nature, speeding the end result, making the patient more comfortable and decreasing the complications and morbidity These points will be amplified in the discussion on compromises which safely can be made in a mass casualty situation.

In a study of a small number of battle casualties dying in a forward hospital, it has been shown that even here one half of the patients died of continued blood loss or irreversible shock while a fourth died of vital organ damage. It is apparent then that even in a hospital environment, blood loss is by far the most frequent cause of death and it is interesting that the casulaties dying of irreversible shock were hospitalized less than five hours after injury were dead in less than 18 hours after injury and had received an average of nearly 10 liters of blood. This clearly points up the time factor the urgency of early replacement and the realization that in a mass disaster neither the blood nor the opportunity for replacement will be early enough. This means again that casualties who cannot survive for 48 hours without treatment are doomed to inevitable death.

IV

PRINCIPLES AND IMPORTANCE OF SORTING

The basic aim of military surgery is to do the most good for the greatest number at the right time and in the proper place Amplification of all the ramifications and corollaries of this one statement would fill a volume and embrace the wisdom of a lifetime of experience The keystone of this basic aim is the categorization of patients into groups so that we give immediate care to those in urgent need, resuscitate those who need this preliminary to definitive treatment, segregate those who can await or who require evacuation to a special center and decide which patients are so seriously injured that treatment will be of no avail. This is the essence of military surgery, whether it be called sorting, triage or categorization of patients for care Another term for this process is the practical application of surgical judgment. Basically this means a budgeting of time, personnel and supplies to prevent waste and assure maximum use of facilities. Sir Isaac Pitman has said that well-arranged time is the surest mark of a well-arranged mind and the proper budgeting of time is a hard lesson for civilian doctors to learn In civilian practice rarely does a doctor have very many urgent cases at any one time and he may laudably sit up all night with one patient. In combat surgery and in mass casualty work, the doctor must realize that there may be tens or hundreds of patients awaiting his services and fruitless

work on a hopeless case or too definitive a procedure on a patient who could wait without harm, may allow another patient to die for want of a hemostat applied to a bleeding vessel. With an overabundance of patients and a shortage of doctors it is inevitable that some patients will die while awaiting care but still the objective is the most good for the greatest number Sorting of patients must be bal anced against availabilities of time personnel and supplies because it is useless to decide on an abdominal exploration if there is no surgeon. Whatever success is attained in the treatment of mass casualties will be based on the proper sorting of patients and application of surgical judgment as to priorities for treatment.

Philosophy of Sorting

The placing of patients into treatment groups requires great moral courage as well as surgical judgment because to deny treatment to one while offering it to another is apt to be misunderstood. Even doctors raise some very immature objections, especially to denying definitive care to the hopelessly injured. Even certified surgeons have stated at national meetings that no one has the authority to assume the responsibility of Deity in deciding who will live and who will die! *Let us not become emotional* about this matter because surgeons make such decisions in everyday practice. When ever the surgeon decides that a disease is too far advanced to permit operation or at operation decides that resection is impossible he makes this same decision, the only difference being in point of time. In the battle casualty case, the immediacy of his act is readily apparent because that patient expires in minutes or hours whereas in the cancer case his decision does not result in death for weeks or even months. There *is nothing new or alarming about this type of decision.*

This pseudo-theological attitude is similar to the ethical point of emotional nature which urges "save the women and children first." Again, sociological or economic points might be raised in favor of treating the bank president first while requiring the janitor to await his economic turn These points sound absurd but have been raised seriously by people who should know better Obviously, none of these points will be given any weight as all patients allegedly are equal in the sight of Deity and the law Equally unsound arguments have been raised regarding the utilization of supplies With 500 patients in shock and one pint of blood available, shall we give each his just share of 1 cc. each or shall we select the patient most likely to benefit? This extraordinary lack of common sense was seen in a certain foreign country after World War II where antibiotics were very scarce. If one ampul of penicillin became available, it was diluted and each patient received his homeopathic share It is said that in one POW camp over 100 prisoners had malaria and suddenly one bottle of 100 tablets of quinine was released. Is the dosage to be one tablet per patient, benefitting no one? These concepts seem so elementary that it should not be necessary to mention them but experience has shown that they must be spelled out for the benefit of the sentimentalists, the do-gooders, the naive and the inexperienced It is obvious that we will stick to proven principles doing whatever is possible to accomplish the most good for the greatest number This is a very heavy responsibility and it is for this reason that the most experienced surgeon must accept the duty of sorting officer His surgical judgment is essential here, whereas someone of less experience can give the definitive care.

Sorting, A Continuing Process

Not only are the decisions of sorting balanced against availability of time, personnel and supplies but this sorting of patients must not be considered as a one-time irrevocable decision from which there is no appeal. Sorting is a continuous and continuing process in two regards. First, changes in availability of personnel and supplies make necessary a quick review of the situation with either up or downgrading of patient priorities in the light of the changed potentialities Second, changes in the patient s condition require review of their priority so that patients who respond to resuscitative measures may be placed in the immediate treatment group while those who fail to respond, remain and those who deteriorate while under resuscitation may be placed in the expectant group Finally sorting is reviewed and redone at each stop in the chain of treatment or the chain of evacuation. A patient who is to await evacuation from a forward center may enter the immediate treatment category on arrival at a special treatment center This concept of continuing reevaluation takes away some of the apparent harshness of the sorting process.

Not only must patients be placed in treatment groups but procedures must be categorized as to priority based again on available time, personnel and supplies For example, as the mass disaster situation develops and the case load increases, it may be necessary to drop off gradually the procedures which take the most time or the most supplies or the procedures which experience has shown to give the least return in lives and limbs saved. This will be discussed in detail in the section of treatment compromises and sounds less grim with more elucidation. Nonetheless, the situation does become grim and the decisions become more and more repugnant. However

we may have to become much tougher in our thinking even considering using the moribund as exsanguination donors.

Selection of Triage Officer and His Duties

From the discussion of sorting it should be clear that the decisions which must be made require the surgical judgment, experience and moral courage possessed by the most senior surgeon present for duty Some plans have called for junior surgeons or even paramedical persons to do this job but such plans are not well con ceived Equally unacceptable is the thought that the Chief of Medicine should be the triage officer The Chief of Medicine is no more able to exercise surgical judgment than the Chief of Surgery is able to assume responsibility for diabetic coma or coronary thrombosis Equally reprehensible is the plan to assign too many people to the triage point. As has been pointed out in the section on hospital plans the triage officer needs a crew to help expose patients for examination a clerk to write down diagnosis, treatment group and ward, a senior resident to perform the occasional emergency lifesaving procedure such as tracheotomy, a junior resident to assist and to stop bleeding by pressure dressings and a series of litter bearers. This in summary states who should be triage officer and what he is expected to accomplish. More he cannot encompass and less would be wasteful of his talents.

V

TREATMENT GROUPS

Since sorting of *patients implies categorizing into* fairly definite groups for treatment, the criteria for such grouping must be established in advance. Also it is helpful to make some rough estimates as to what per cent of the total case load probably will fall into each group This gives some indication as to the scope of our planning for personnel and supplies In addition, it indicates clearly some of the restrictions that will be placed on treatment by obvious inability to furnish the wherewithal.

Casualties seem to fall into four natural categories and these have been formalized into Treatment Groups. There are the walking wounded, well known in combat surgery and the various non-effectives who need very little specialized care making up the Minimal Treatment Group Next are the casualties who obviously require Immediate Treatment if they are to survive. Then there are the casualties who require resuscitative measures before coming to operation or whose condition will not deteriorate unduly by a period of waiting, making up the Delayed Treatment Group Finally there are those patients who are *so seriously injured that survival cannot* be anticipated or patients for whom necessary treatment facilities are not available. These make up the Expectant Treatment Group Originally it was estimated that with an atomic attack or a large civil disaster the patients might group themselves as follows

Treatment Group	*With Civil Disaster*
Minimal	40%
Immediate	20%
Delayed	20%
Expectant	20%

More recently with planning for thermonuclear attack and staggering numbers of casualties, estimates have been changed as follows

Treatment Group	*Thermonuclear Attack*
Minimal	45%
Immediate	5%
Delayed	45%
Expectant	5%

The reasoning behind these changes are: first, with a larger area of involvement the periphery of damage will be larger and consequently there will be a greater area in which injuries will be incurred Next, with tremendous numbers of casualties there will be greater difficulty in evacuation of patients so that fewer may live to reach a medical center Also, medical facilities will be overwhelmed and the more serious case groups will have to be dropped from consideration for definitive surgery because of lack of time personnel and supplies This means that although the Immediate Treatment Group may be tremendous in size it will actually make up a much smaller percentage of the whole. Then, since serious and less rewarding case groups will be dropped off the definitive treatment list, these cases will shift to the Delayed Group Also, slower and more difficult evacuation of casualties will mean that patients who otherwise might have been in the Immediate Group, will have deteriorated to the point where they must be put in the Delayed Group Lastly most of the patients who ordinarily would go into the Expectant Group will have died before being evacuated to a treatment area and the Expectant Group will be made up of deteriorated

patients from the Delayed Group, plus such cases as severe irradiation injuries These are the rationalizations which influence the estimates on grouping of patients for treatment.

Minimal Treatment Group

These patients, requiring minimal treatment, will make up 40 to 45 per cent of the total load and will fall into two subdivisions.

A. Patients who may return to duty, be released to their own care or who can be put to work after minimal treatment. These patients should be separated from the triage system as early as possible and should not be allowed to get into the hospital area except to work. They should be congregated in the area set aside for walking wounded where they can make up a work pool depending on their capabilities. This group includes

1 Minor lacerations and contusions too serious to ignore but requiring at most a small dressing.
2. Simple fractures of small bones which do not interfere with ambulation or self-care and which can be left untreated or managed by sling or bandage.
3. Second-degree burns of less than 10 per cent body surface which are not incapacitating

B Non-effective patients who have minor injuries or disabilities but who need domiciliary or nursing care. These patients also should be separated early and kept out of the hospital. They may be put in the walking wounded area to be fed and otherwise assisted by other members of their group. This group includes

1. Disabling minor fractures such as those which

prevent the patient from walking or which cause swelling about the eyes to prevent vision

2. Minor burns of the face, hands or feet which are serious only in that they prevent the patient from seeing, walking or feeding himself
3 Moderate psychiatric disorders which would cause the patient to make himself a nuisance rather than an actual menace.

Immediate Care Group

Depending on which figures are used, this group makes up 5 to 20 per cent of the total and is made up as follows

A. Patients hemorrhaging from readily accessible site. This may be an extremity vessel quickly controlled by a pressure dressing but the patient cannot be released or needs subsequent wound debridement. It may be an exposed vessel which can be quickly clamped and tied, the wound being left open and the patient placed in the walking wounded area. It may be a minor maxillo-facial injury where a Barton bandage stops hemorrhage by reapproximation of displaced tissues and the patient then can await debridement or can be placed in the walking wounded area if he can eat.

B Rapidly correctible mechanical respiratory defects such as sucking wounds which require a pressure dressing, tension pneumothorax which requires aspiration, or multiple rib fractures where immediate tracheotomy will relieve pain, stop paradoxial motion and improve ventilation to the point where cyanosis disappears

C Severe crushing wounds of the extremities where bleeding may be a problem or where the devitalized tissues cause damaging absorption or where a

dangling part complicates nursing care. Here, it may be best to complete the partial but inevitable amputation or a physiological amputation may be accomplished by applying a tight tourniquet which is not to be removed until definitive amputation is done

D Severe lacerations and open (compound) fractures obviously require debridement, immobilization and subsequent delayed closure.

E. Severe burns of the face or upper respiratory tract require immediate tracheotomy and then may need no further definitive treatment except supportive care.

Delayed Care Group

Again depending upon figures quoted, this group will make up 20 to 45 per cent of the total group Casualties placed in this group will be those whose surgical treat ment can be delayed without immediate jeopardy to life or those who require resuscitative treatment in prepara tion for operative treatment. There will be marked variation in concept regarding this group For example, if a patient requires only blood transfusion before wound debridement and there is not too great a backlog of cases he may be placed in the immediate group to get his blood while awaiting operative scheduling Further if abdominal injuries are to be treated by operation, they may be placed in the delayed group to receive blood and antibiotics before operation If operation is beyond the scope of availability of time personnel and supplies, abdominal injuries may drop in priority to the expectant group for conservative management. This shows how circumstances modify these codifications which never can be absolute but depend on current judgment. Ord-

inarily the delayed care group will include

A. Closed fractures of major bones These will be treated by splinting and immobilization which will allow them to wait indefinitely if necessary Deformity and non-union will have been accepted as inevitable.

B Moderate lacerations without severe hemorrhage can be treated by antibiotic coverage and pressure dressings Debridement within 72 hours should be hoped for but unless definitive debridement can be done the patient might better be left alone with these conservative measures An infected wound will be commonplace.

C Burns of second degree involving 10 to 40 per cent of the body surface or third-dergee burns of 10 to 30 per cent extent require fluids and antibiotics if available but do not require operating room care and, therefore, are placed in the delayed group. Minimal debridement on the ward will be helpful and exposure treatment probably will be the rule whether or not the case fits the usual criteria for that method.

D Non-critical central nervous system injuries will include everything not placed in the expectant group because these patients tolerate delay very well and probably the policy will be not to operate early anyway This will be elaborated upon later

Expectant Group

This is the most controversial group because this 5 to 20 per cent of the case load will be made up of patients who cannot be treated by the usual means because of unavailability of time personnel or supplies and patients who are so seriously injured that their death seems in-

evitable based on past experience. Herein will be included

A. Critical central nervous injuries and severe respiratory system injuries. These patients will be made comfortable and observed. Some will survive but the majority will succumb

B Abdominal wounds will be placed in the expectant group because abdominal exploration is so costly in terms of time and supplies, because surgeons of the caliber needed for this work will not be available and because, as will be pointed out later, there is a moderate return from conservative therapy alone. These patients will receive fluids and antibiotics parenterally if available and nasogastric siphonage if possible.

C. Multiple severe injuries obviously critical in nature. This group requires little discussion except to caution that some wounds such as those of the face and neck may look perfectly terrible but respond to simple tissue replacement by a Barton bandage. A little experience will indicate what types and severities of multiple wounds are incompatible with life. Such patients should be made comfortable.

D Burns of second or third degree of 40 per cent body surface or more, should be given sedation. As will be shown later heroic measures may prolong life past the shock stage only to have the patient die of septicemia. Burn research has prolonged life in such cases but has not changed the mortality rate significantly and we can tell almost *mathematically by degree and body extent*, which patients will die in spite of all efforts. The occasional patient who survives will not be given the opportunity in mass casualty situations

E. Obvious cases of lethal irradiation injury need be treated because at best we have no spec therapy Lesser degrees of irradiation injury h been omitted from consideration in the ab groupings because we cannt tell how much irra tion a patient has sustained and division by ro gens is entirely academic. Only time will make groupings in irradiated cases

Priorities for Treatment

No matter by what criteria patients are categori into treatment groups, the same two conditions ren at the top of the list, patients who are losing blood patients who have some interference with free breath These two conditions are of equal importance and interrelated that priority between the two will vary v the individual case. It has been shown that difficul in one or both of these fields cause most of the de from trauma in the first 48 hours and it is known whole blood will be an extremely scarce commodity a disaster situation. Consequently, blood loss of e small amounts must be stopped at the earliest poss moment as definitive therapy but more especially a prophylactic measure against development of shock. ternal hemorrhage is simplest to control by such m ures as pressure dressing, hemostat and ligature or initive tourniquet. Internal blood loss is more diffi to recognize and with the low priority for abdominal thoracic operations in case of disaster, such pati probably will be lost. Cardiorespiratory embarrassn may be on the very simple basis of displaced tissues f maxillo-facial injury, quickly corrected by a Ba bandage. Sucking chest wounds respond to an occlu dressing and tension pneumothorax to a needle v

Most thoracic bleeding will be from the chest wall or from vessels other than those in the lung tissue. For this reason *thoracotomy either is not required or probably* will not be done soon enough to be valuable anyway Control of hemorrhage and maintenance of an airway fall into the field of first-aid and take precedence from that time on, coming ahead of any thought of therapy by definitive case groups.

Priority by Case Groups

Only after hemorrhage is controlled, blood replacement has been started and an adequate airway is assured, is it time to think of therapy for the wounds themselves. It probably is true that treatment of burns will be the simplest and most nearly routine of any of the case groups because simple debridement, plus fluid administration, will constitute the regimen, plus injection of a tetanus booster and antibiotics if they are available. These cases will not go to the operating rooms even if tracheotomy is needed unless a concomitant injury requires surgery This case group therefore, is relegated to ward care.

Extensive soft tissue injuries will be the first case types taken to the operating rooms not only because they make up the bulk of the total case load and the salvage rate from such cases will be high but because the specialized and *time-personnel-supply consuming cases* will be deleted from consideration. It is important to remember that turning and moving a patient causes and augments blood pressure drop so that if there are wounds of the sacrum and buttocks plus anterior wounds, the posterior *wounds should be debrided first to eliminate one turning.*

Open fractures will be dealt with at the same time as soft tissue wounds are debrided, using the quickest and

ılest method of reduction and fragment fixation not to conserve time but because extensive bone work in ıfected field is poor judgment. Closed fractures take priority except for splinting.

abdominal wounds are to be operated upon this ıld be accomplished in the first eight to twelve hours ents who survive the initial period stand a good nce of spontaneous recovery, with the various com ations of peritonitis fistula and adhesions, but recover etheless. It seems obvious that in a mass disaster cases of abdominal injury may not be rescued dur this "golden period" and for reasons of economy, servative therapy may be most rewarding Conse ntly, abdominal wounds drop from first priority in mal times to no priority for operation in disaster ːumstances. That this is not entirely reprehensible l be shown.

Vounds of the external genitalia will be handled as soft tissue wounds with the special requirement that vision must be made for the urinary stream either by stostomy or urethral catheter, keeping in mind the ulability of catheters and such apparatus Wounds of internal genitourinary system are considered with dominal wounds and will be managed conservatively abdominal wounds are not explored or will be appro lately treated at laparotomy This is a small case oup at best.

Central nervous system wounds have low or no priority r operation in a mass disaster because of shortages of rsonnel, length of time required, relatively low yield useful salvage and also because as will be shown, ese cases deteriorate slowly even if not operated upon.

Maxillo-facial and eye cases will have low or no priority r operation except for control of hemorrhage and main

tenance of airway Sight-saving is extremely important but will have to be balanced against capabilities and efforts at lifesaving.

VI
COST OF DELAYED MEDICAL CARE

In previous sections it has been hinted that the picture is not entirely black even if nothing more than a little supportive care is given and it has been stated that medical treatment is much more in the nature of supporting survival than it is of actual saving of life. It is known that after the bombing of Hiroshima and Nagasaki, there was little effective medical care in the first week and, therefore, it is obvious that those who survived did so because of their inherent ability to cope with injury and in spite of the absence of medical care. The United States Strategic Bomb Survey estimates that only 5 to 8 per cent of lives lost could possibly have been saved by the best medical care. This correlates with and corroborates the previous statement that casualties who die in the first 48 hours do so because of hemorrhage, asphyxia and irreparable organ damage all of which are too sudden or severe to respond to medical care. This means, therefore, that early adequate medical care is much more effective in improving late results rather than early mortality This is another way of saying that we can influence the DOW (died of wounds) rate by improved methods but the KIA (killed in action) rate remains quite constant. This brings up two very interesting points which at first glance seem unrelated—city use of ambulances and location of military hospitals in combat.

People in most enlightened communities realize that

the racing, screaming ambulances with sirens blowing and lights flashing rarely accomplish a lifesaving mission and frequently cause serious traffic accidents. A check on what the ambulance contains most often is a sad commentary on human intelligence In almost no instance do a few minutes make any difference and if the situation is that serious the patient will die in receiving room, in spite of emergency care and without ever getting to the ward. Ambulances should use lights and sirens to clear right of way but should obey traffic signals including stop signs and red lights Any other course is founded in sentiment and emotion rather than in necessity Lest these comments be considered only as ill-tempered generalizations, let us cite some figures. In Flint, Michigan, in the summer of 1949 an ambulance ran a red light, struck an automobile and killed the young ambulance driver Three weeks later an ambulance driver for the same company traveling 70 miles an hour ran a red light, crashed into a truck and killed the driver These incidents were the cause for setting up a central dispatch system under police control.

Formerly ambulances raced to the scene of the accident to secure the business for their company but now they are police-directed and limited to 35 miles per hour That speed is not necessary to save lives is shown by the fact that an ambulance averaging 30 miles per hour travels five miles in ten minutes and at 60 miles per hour only five minutes would be saved. That the time factor is relatively unimportant is shown by analysis of 2,500 consecutive ambulance runs in Flint, showing that this additional five minutes would not have influenced the course of a single injury Of these 2,500 cases 27 were dead on arrival and 13 died in the receiving room. Careful autopsies convincingly showed that not one of these

cases would have survived had the injury ocurred on the hospital threshold In these 2 500 consecutive runs, haste was totally unnecessary in 98.2 per cent and in 1.8 per cent expeditious handling was considered wise but a speeding ambulance would have increased the degree of injury More important than speed is proper first aid and proper transportation precautions to prevent augmentation of injury The Subcommittee on Transportation of the Committee on Trauma of the American College of Surgeons surveyed 62 cities and found that 28 per cent showed only fair to poor in this regard One out of four communities with substandard transportation of the injured certainly indicates an area where improvement is possible.

Military hospitals may be located so near the front line action that a high percentage of hopelessly injured casualties will live to reach the hospital alive only to die of their wounds inevitably In this situation time and supplies are wasted and care is denied to casualties who might be saved if treated. Such a hospital will have a high case fatality rate If located a few more miles back from the front lines fewer hopelessly injured would live to reach the hospital medical care could be expended on patients more able to profit by it and case fatality would be reduced. In a mass casualty situation the time lag will be such that most hopelessly injured will die before getting to the treatment area and thus medical effort will be conserved for a more useful application

Howard and DeBakey have made a careful analysis of the cost of delayed medical care and have furnished additional evidence that early medical care is more important in preventing late deaths from complications and sequelae than it is in preventing early deaths within the first 48 hours. Comparison of results from the Crimean

War when medical treatment was essentially non-existent with results from World War II indicates that an additional 12.5 per cent might have been saved in the Crimean War by early care This does not consider thermal and irradiation injuries which we see in current times and these would wipe out at least half of this 12.5 per cent. Various statistical analyses show that early treatment, even within 12 hours of injury, would save only an additional three or four individuals per hundred casualties This brings to mind the suggestion that the artificial kidney be wheeled out onto the battlefield for the benefit of the one or two per hundred who might need it and the fraction of those who would survive with its use. Many times the terrific expense and logistical difficulties make it entirely impossible to afford some procedure which might benefit a fraction of a per cent of individuals. Common sense and not emotionalism or sentimentality must prevail, especially in times of disaster

Wound infection will be a distinct problem following mass disaster because with each hour of delay before wound debridement there will be a definitive increase in bacterial growth. Obviously all wounds and second or third degree burns will be contaminated originally and most will develop frank wound infections if treatment is delayed. Even in a civilian hospital series where early wound debridement was done Meleney found a 17 6 per cent incidence of wound infection in soft tissue injuries and a 25.5 per cent incidence of infection in open fractures. In burn cases second degree burns showed a 25 per cent incidence of infection, third degree burns showed 68 per cent and the overall incidence of infection in treated burns was 46.5 per cent. Such wound infections will cause considerable morbidity but not a high immediate mortality Clostridial myositis (gas gan-

grene) on the other hand has been an important cause of death in past wars where debridement and antibiotics were used late or not at all In World War I, soft tissue wounds showed an incidence of gas gangrene of from 1 to 5 percent with a 27 per cent mortality rate In Korea with early debridement and antibiotics, the incidence of gas gangrene was a fraction of 1 per cent with no mortality Debridement and antibiotics within the first 12 hours will prevent mortality from gas gangrene but treatment instituted after 48 hours will show an incidence of 5 to 10 per cent of gas gangrene with a mortality rate of between 30 to 50 per cent. An amputation rate of about 4 per cent from effects of infection is reasonable to expect. Since soft tissue wounds of the extrementies will make up at least 60 per cent of the casualties, it is clear that early debridement and antibiotic administration would give an extremely high salvage rate and good return for time and effort expended. Such wounds probably will be seen after 48 hours and still, debridement and antibiotics will be highly profitable although more and more amputations will be necessary as delay increases. This shows the reason for the continual emphasis on wound debridement as a mainstay of treatment in disaster Tetanus will not be a great problem because of the almost universal immunization of the population, either primarily as in the military group or in combination with diphtheria inoculations in civilians. In non immunized populations tetanus will be a problem as it was among civilians in Manila in World War II At present there is no substitute for wound debridement. Local application of drugs is ineffectual and systemic antibiotics alone only delay onset of infection, at best. However, wound incision as a substitute for debridement may only succeed in dislodging blood clots which are pre-

venting exsanguination and pressure dressings plus systemic antibiotics must suffice until full scale debridement is possible.

Burns will make up the next largest case group and will be an important problem. Second and third degree burns do not, by their nature, lend themselves to debridement as do soft tissue wounds all of the burns will be contaminated, the vast majority will develop wound infection and antibiotics are not effectual in undebrided wounds. All this adds up to the statement that early treatment of burns in a mass casualty situation will not be worthwhile except for the administration of fluids. Years of research in the field of burns have reduced the mortality rate by about 10 per cent but this is due almost entirely to the fact that we have learned fluid replacement which obviates death from shock. We have not reduced the death rate from infection even with the highly touted antibiotics and burn patients taking multi valent and multitype antibiotics now die of overgrowth of organisms which ordinarily are saprophytic rather than pathogenic. Death rate from burns increases with the surface area burned and we know that few patients with a 40 per cent surface burn will survive. We may summarize all this by saying that patients who used to die early of shock now survive to die later of infection. In a mass casualty situation, there is no point in wasting time in a valiant struggle to save patients who inevitably will die in ten days This is the reason for saying that 40 per cent surface burns will be placed in the expectant group to be made as comfortable as possible. Patients with burns up to 20 per cent of body surface can take fluids by mouth and patients with over 40 per cent burn probably will not be treated so that the 20 to 40 per cent group requires fluids, intravenously if possible. Probably

most will have to sip fluids by mouth and succumb if they are too nauseated

Central nervous system injuries are dramatic, require highly specialized care which may be unavailable, at least among paraplegics show a poor economic salvage rate, and in a mass casualty situation will have almost no priority for operation Closed head injuries rarely require operation so that conservative therapy here in the usual course of delay due to disaster situations will not materially affect this group Paraplegics will not be operated upon and most of them will die. This harsh statement is made with apologies to the many paraplegics who have made a good adjustment after years of skilled treatment in mutiple hands and at an expense of thousands of dollars Disaster circumstances will make this a luxury which cannot be afforded This leaves the open head injuries and, interestingly enough, even the through and through gunshot wounds with coma do not appreciably deteriorate in 48 to 72 hours This is because of the traumatic decompression and they do not develop infection till after the 72 hour period This is a small case group for which skilled personnel will not be available and fortunately they tolerate delay very well

Thoracic injuries make up a small case group and fortunately thoracotomy rarely is indicated In a mass casualty situation and patient who requires thoracotomy probably will not live to reach a place where it can be done and consequently this case group will be handled almost entirely by aspiration for removal of air and blood closure for sucking wounds and traceotomy for crushed rib cage Figures show a 7 per cent mortality for patients treated within the first 12 hours with a rise to 30 per cent for patients whose therapy is delayed until after 12 hours This indicates that early therapy in this group

is highly worthwhile because the treatment is simple and the salvage rate is high. Delay in treatment results in death from bleeding and/or respiratory embarrassment before infection can develop so that empyema is not a factor in early mortality

Abdominal injuries make up a very small case group and, therefore, the reduction in mortality rate from 32 per cent before World War II, to 19 per cent for World War II and to 8 per cent for Korea is dramatic but not highly significant in actual number of patients Howard and DeBakey estimate a 0.5 per cent increase in mortality rate per hour of delay or not over 3 per cent for a delay of 48 hours We tend to forget that abdominal inujries were not operated upon in World War I and surgery for abdominal injuries originated within the memories of most of us Abdominal operation requires more training and skill than the other battle casualty cases except neurosurgical cases and is very time-consuming. Since neither time nor skilled surgeons will be available, conservative treatment will previal. Furthermore, delay of 48 hours in pickup of casualties is to be anticipated so that the majority of patients who live to reach the treat ment area will survive anyway Stated positively even without operation, 68 out of each 100 abdominal injury cases will survive. This is a rather optimistic picture and certainly does not mean abandonment for the group.

Vascular surgery came into its own in Korea because the pace of the war was slow so that time was available, distances were short so that casualties were seen early and the young surgeons were skilled in vascular suture techniques It is almost unfortunate that the results were so good because the young surgeons who had never seen any other war felt that this set a precedent for future wars which certainly may not be the case. Liga

tion of injured peripheral vessels was practiced in World War II and resulted in a 48 per cent amputation rate Primary repair in Korea resulted in a decrease to 13 per cent amputation rate with a 4 per cent mortality rate and a 1 per cent incidence of gas gangrene. These wounds were seen in up to 18 to 24 hours after injury and it seems probable that 18 hours is the longest dura tion of injury which permits much hope of success after vascular repair It is quite certain that in a disaster circumstances, patients will not be available within 18 hours time will be at a premium, skilled vascular sur geons will be otherwise employed and injured peripheral vessels will be treated by ligation

Maxillo-facial casualties lend themselves to debridement and primary repair but in a disaster, only the most serious will be admitted for treatment and if these arrive after 24 hours primary repair will not be feasible These cases will be treated as any open wound without great change in mortality but with a considerable plastic surgery load for future years.

Simple Essential Surgery Possible Under Difficult Circumstances

It will be seen from the foregoing discussion that there are many simple procedures which require little time, limited training and few facilities but yet give a very high return by comparison. In order to do the most good for the greatest number the following procedures should be kept in mind, somewhat in this order

1. Control external hemorrhage by ligation of major arteries especially in the extremities and control lesser hemorrhage by pressure dressing reserving the tourniquet for extremities in which amputa tion is inevitable

2. Perform tracheotomy if indicated and in certain cases prophylactically as in face burns but keep in mind the efficacy of repositioning tissues by Barton bandage to establish an open airway
3 Close sucking wounds of the chest by any means at hand but usually with a pressure dressing which soon becomes soaked with blood, acting as a good escape valve.
4. Control pressure pneumothorax or hemothorax by needle aspiration and if repeated aspirations are needed, if patient transportation is not required, use a tube for water-seal drainage or use a rubber glove finger to make a flutter valve. Usually needle aspiration is highly preferable.
5 Begin to correct the blood deficit in patients who have lost blood and the blood volume deficit in burn patients Do not waste blood and volume expanders on patients who cannot survive, have no priority for operation or in whom fluid loss has not been or cannot be controlled.
6 Treat the burn patients of from 15 to 40 per cent body surface but do not extend beyond these limits since either they do not need it or will not profit by it.
7 Amputate mangled extremities either surgically by guillotine leave-open technique or physiologically by definitive tourniquet. Complete the partial traumatic amputations if restoration is obviously impossible remembering that nerves, blood vessels, muscles, bone and skin are necessary for a worthwhile extremity Saving a non-functional extremity is not a triumph. Remember further that completion of amputation improves hemostasis, nursing care and transportability

8 Splint major fractures to stop progression of shock, improve transportability, and prevent further dam age to nerves blood vessels and prevent com pounding if it has not already occurred

9 Some lists include removal of large foreign bodies but this is certainly a controversial point which needs discussion The patient may be impaled by a plank or picket fence and in many instances to pull out this object without complete operating room control might be fatal from hemorrhage or highly inadvisable because of evisceration Here, a simple saw might remove the excess foreign body and allow transportation of the patient to better facilities. Further a foreign body protruding from the skull may be plugging a venous sinus and its injudicious removal might allow or cause fatal hemorrhage.

10 Up to this point the simple procedures listed have not even necessarily required an operating room When these procedures have been done, or patients are seen at a place where more definitive care is possible and available the case groups then are cared for in the priority mentioned elsewhere, according to surgical judgment.

VII
CHEMICAL AND BACTERIOLOGICAL WARFARE

Chemical Warfare

By definition a chemical agent is any gas, liquid or solid which through its chemical properties produces a lethal, injurious or damaging effect upon man, his animals his crops or his equipment, one which produces a signaling or screening smoke or one which produces an incendiary action. From this broad definition arises the semantic difficulty in political or ideological discussions about the war in Korea. The "yes you did," "I did not," type of argument fails to define its terms. In Korea, smokes and incendiaries were used but none of the primarily antipersonnel agents have been employed since World War I. Incendiaries have been used since 404 B C. but the first anti personnel agents were used by the Germans in World War I. In other wars, the fear of gas attack has been a harassing factor and has caused troops to lug gas masks through all manner of swamps, jungles, mountains and plains.

We can dismiss the incendiaries by saying that they are used primarily against materiel but cause serious personnel damage and death from burns. These agents pose only the problem of treatment of burns.

There are essentially six types of anti-personnel gas agents, the tear gases (lacrimators) and vomiting gases (sternutators) which are harassing agents and the four

casualty producing groups which are the choking gases (lung irritants), blood gases (systemic poisons), blister gases (vesicants) and the nerve gases

Potentialities

The tear gases find their greatest usefulness in police action to bring an unprotected individual under control or into the open In warfare these gases have too many disadvantages and little to commend them The vomit ing gases were designed as a smoke to penetrate gas masks, thus causing the necessity of removing the mask to vomit. During this interval, some more potent chemical agent could be inhaled with serious effect. The lung irritants are represented by phosgene which causes both armies to mask, depending on wind or other factors and, therefore, little value accrues. The systemic poisons are represented by cyanide gases which were used by the French in World War I with little effect and have been essentially discarded. The vesicants represented by ars enical compounds or nitrogen and sulfur mustards up until the advent of the nerve gases were the most potent and potentially useful of the anti personnel agents. Their effects are well known and their main disadvantage lies in their persistence which may deny a contaminated area to troop occupation for a disconcerting period. It is doubtful if any of these well known agents will see ex tensive use again because more potent agents are avail able with fewer disadvantages.

Nerve Gas

The nerve gases Tabun, Sarin and Somen were developed before and during World War II by the Germans incident to research in insecticides Large amounts were

stockpiled but it is stated that the reason it was not used was that German intelligence agents thought we had it also We were busy making DDT insecticide, whereas the Germans thought we were making nerve gases. All of the nerve gases are substituted phosphoric acid esters which vary greatly but all are extremely dangerous agents which offer the greatest current threat. They evaporate to form highly toxic gases or as liquids they easily penetrate eyes mucous membranes or skin. These agents react with the enzyme cholinesterase in an ir reversible inhibiting reaction in tissue fluids permitting accumulation of acetylcholine and continual stimulation of the para sympathetic nervous system. The nerve gases are essentially odorless and colorless and one of their most cogent advantages is the extreme rapidity with which they act, death following exposure in a matter of five minutes or less. The clinical picture resembles muscarine or nicotine poisoning with profuse nasal discharge feeling of tightness in the chest, dimness of vision, pain in the eyes, headache, difficulty in inhaling and exhaling excessive salivation, and sweating, nausea, vomiting, loss of sphincter control, clonic and tonic convulsions confusion, drowsiness coma and death.

Treatment

Immediate parenteral administration of heroic doses of atropine is the only successful antidote, giving 2 milligrams preferably intravenously and repeating every few minutes until 6 to 10 milligrams of atropine have been given. Smaller repeated doses for several days may be needed. It is apparent that nerve gas contaminating a city would be a highly effectual way of eliminating most, if not all, of the population. These gases vary in persistence so that the city would not necessarily be denied

for occupancy by enemy troops Since the agents kill so terribly rapidly, treatment is almost an academic consideration because there will be no time to evacuate casualties nor can rescue workers get in Self administration of atropine has been proposed but elsewhere we have commented on the inability of disciplined soldiers to inject themselves in a trial run It is highly unlikely that citizens can be induced to carry the syrettes at all times much less self-administer them effectually

When the stage of respiratory paralysis has been reached in a matter of seconds or minutes, artificial respiration is necessary and the extreme degree of bronchial secretion makes tracheotomy for suction clearance necessary This explains the flurry of interest in artificial respiration and tracheotomy about the country Here again, we run up against the time factor and the absence of people to perform these acts. Individuals simply cannot tracheotomize each other in a matter of seconds and if they do they are immediately eliminated from the possibility of using mouth to-mouth artificial respiration on each other These are mutually exclusive Thinking on this problem will have to be much better than it has been in the past because many of the proposals are so obviously foolish If we cannot even interest people in simple aspects of civil defense, it is entirely futile to expect each individual to carry at all times on his person, gas mask, dosimeter atropine syrettes, tracheotomy tube plus Dextran and pressure dressings The simple matter of supply alone is interesting in that a fabulous amount of atropine in a tremendous number of syrettes would be needed and a physical count of available tracheotomy tubes is indeed revealing

It is perfectly possible that the nerve gases may make entirely obsolete the atomic and thermonuclear weapons

which destroy structures and lay waste territory whi invading troop could well use. Since treatment seer almost out of the question, even the threat of nerve g attack should be more of a deterrent than threat thermonuclear attack. Could it be that availability nerve gases might stalemate war?

Bacteriological Warfare

Bacteria and bacterial products have been consider as agents of warfare against man, animals and cro but probably have not yet been used. This subject len itself well to scare headlines and has been a favorite Su day supplement topic. The most difficult problem wou be the mass production and storage of the toxin whi would have to be stable for long periods or the rap production of large volumes of organisms for live deliver The next problem would be the accurate delivery of th toxin or the delivery of the organisms in viable cond tion. There are so many difficulties involved that th effectual use of bacteriological warfare seems unlikel Use as a sabotage agent is more within the realm possibility

Potential Uses

For use against personnel it is not necessary to k but merely to disable temporarily Bacteriological wa fare would not necessarily deny a city to occupyin troops although the city water supply was not potab in Tokyo for nearly two years just from the accident contamination incident to the many leaks from bombin Bacteriological warfare would not destory buildings an on first thought might seem to be a quite humane an highly successful operation.

Introduction of a toxin into the water supply woul

be the simplest theoretical way to cause the city defe
ers to be otherwise occupied with diarrhea and vomiti
However, this is not as simple as adding knock-out dr
to one drink. To simultaneously introduce enough to
into all the sources of water supply would pose a c
siderable problem in logistics

The introduction of bacteria to cause actual disc
among the population is even more difficult althou
respiratory insect borne and water-carried organi
could be considered. Here, the logistic problems wo
be even more difficult, plus the added problems of
livering a live organism consideration of the incuba
period of the disease, possible immunity among the p
ulation and other such factors At best, this would
more of a sabotage factor than a decisive war effort

Similarly sabotage might be directed at industry
an attempt to contaminate foods soft drinks milk
water supplies Attacks on animals might be made
reduce the meat supply but this would be a slow pro
over a period of time. For example, areas might
contaminated by organisms of glanders or hoof
mouth disease. Dusting of agents to kill plant c
again might be feasible but constitutes a slow long ra
type attack which probably would hardly be worth
effort and expense

Methods of Prevention

Continuation of high standards of food inspection,
adequate checks on milk and water supplies, m
attacks from this angle difficult and unlikely Main
ance of immunization programs among the popula
and continuation of high standards of individual he
should foil most attempts to start an epidemic. Pu
health control of insects and rodents should al

eliminate the danger of vectors from this directio
in all, bacteriological attack on a civilized nation
be most difficult but might succeed better on a c
with low standards of living and health.

Treatment

Treatment of attack on humans would be by l
doses of immunizing agents, specific sera adminis
if applicable, isolation, decontamination, selecting
nate water or milk supplies, and other measures b
dividual and general to eliminate or neutralize the
or treat the patients.

VIII
LESSONS LEARNED FROM CIVILIAN DISASTERS

It is difficult to evaluate past events because hindsight shows errors of commission and omission in such a bright light. Further, emotional overtones become more prominent and individuals concerned have time to rationalize their actions so that everything looks rosy, only the favorable aspects being remembered. Unfortunately we make little progress unless we remember our mistakes and profit by them by better planning and better training. Santayana has well said that those who cannot remember the past are doomed to repeat its mistakes With these thoughts in mind it seems important to review what has happened in some civilian disasters in order to see where we have failed and to determine how we can do better Since such evaluations and remarks carry a critical connotation, we will not identify the disasters by city name but will present factual documented comments on actual situations It is hoped that this pseudo-anonymity will sufficiently protect any toes which are trampled and egos which are fractured. Our intent is not to point the finger of scorn or ridicule but to point the way to more effectual action in the future.

A Train Wreck

In the past few years there have been two serious train wrecks in an eastern city about a year apart. The first one

generated about 200 casualties. The wreck was in hours of darkness and rescue work continued all night, being hampered seriously by onlookers and traffic problems. Hospitalization of this number of casualities was accomplished with great difficulty, sending some to an adjacent metropolis This wreck spurred considerable planning and training so that when the next wreck occurred, evacuation and hospitalization were much smoother Newspaper comment was highly favorable regarding this second wreck. This indicates that when stimulated, people will train and prepare but they never seem to do these things until after the fact. In a western city a daytime train wreck engendered 150 casualties and the city transportation and hospitalization facilities were severely taxed. In some way it should be possible to point out that a thermonuclear weapon might have the effect of 100 such train wrecks simultaneously in a city of this size. Without planning, organizing, training and testing the plan, chaos attendant upon civil disaster will be incalculable. Women s clubs might well engage in such projects instead of dabbling in foreign policy running of orphanages in Timbuctu or Hottentot theories of flower arranging.

Even small numbers of casualties can disrupt the functioning of the ordinary hospital not trained for management of disasters but just a minimum of preparation makes a world of difference. At a small military hospital on the evening after a meeting to discuss the hospital emergency plan, a nearby train wreck caused 30 seriously injured patients to appear The majority were taken to wards and only two went directly to the operating rooms. Antibiotic, intravenous and immunization teams were formed and within two hours all the patients were in beds and under treatment. Within two more hours all shock cases were stabilized. The next morning litter teams

carried the patients to X ray and before noon all films were taken. Curiosity seekers were sent away and a public information office functioned to issue bulletins and answer calls This small disaster, handled with commend able dispatch, shows the value of advance planning and training. Much time was lost by personnel not knowing where items of supply and equipment were located in the various departments pointing up the value of complete labelling and the standardization in methods of storing in various wards. Non-professional ward personnel did most of the nursing procedures with nurses acting as supervisors, indicating the importance of such training. The successful management of this small disaster gave this staff considerable satisfaction and settled many doubts and misgivings about their capabilities under stress.

In a small civilian hospital which had no emergency plan but where the lay administrator had given the problem some thought, a train wreck in mid morning brought a sudden influx of casualties The police were early on the scene of the wreck, alerted the hospital and called for additional police. The hospital notified its 25 doctors, half of whom went to the scene to give first-aid and the other half went to the hospital to begin treatment. Within two hours 103 patients were received and there were no deaths in the group As fast as doctors could be released from the accident site, they returned to the hospital to assist in treatment. Records and orders became a problem but all who received tetanus toxoid were identi fied by a red T painted on the dorsum of the hand. All patients were brought to the hospital so that a complete roster could be made for record and to locate individuals. Walking wounded were congregated in the dining room and the others were sorted for care Twenty reporters and photographers arrived with the first patients and

were given complete freedom as long as they made no interference. The calm behavior and lack of hysteria among the patients all of whom were children, were noteworthy One problem which interests a civilian hospital is the distribution of patients to specific doctors equitably so that fees can be charged although in some disasters, doctors have agreed to submit no bills. Military physicians are fortunate in being able to by pass this aspect of the problem. Problems included lack of triage space, lack of bed facilities in an already full hospital, lack of additional *supplies and, in particular lack of reserve supplies* of blood or volume expanders X ray supplies and tetanus toxoid. It was stressed that first aid and minor cases must be kept out of the operating suite in order to have space *for routine emergency cases and serious cases from the* disaster itself

A Bridge Collapse

In a town of 7,276 population, a bridge collapsed during the daytime injuring thirty workmen. This completely paralyzed local medical facilities to the point where hospital beds, intravenous fluids, dressings surgical instruments and even surgical operating teams had to be requested from a large city two hundred miles away Even with this assistance, it was not possible to handle these thirty casualties and the more seriously injured patients were transported to the city for operation. In spite of this influx of supplies and personnel, plus the evacuation of the more serious cases the last patient was not operated upon until 72 hours had elapsed. This is an incident of 1955 and brings out the point that instead of the small town being able to send supplies and teams to help the large city in disaster the town cannot even cope with thirty patients of its own. To expect small towns and out

lying communities to send teams is to expect a higher level of training and organization than now exists and probably is wishful thinking

An Earthquake

We tend to feel that mass disaster originated with the atomic bomb, forgetting that within the lifetime of many of us an earthquake devastated one of our cities, setting a fire which burned three days, reached a temperature of 2,000 degrees in the fire storm and cast enough light to read by 40 miles away Two thousand six hundred acres in the heart of the city were laid waste, an area of 490 city blocks destroyed and 32 blocks partially destroyed, leaving 225 000 to 265,000 homeless, between 452 and 498 dead and 1,500 injured In less than three hours, the Army turned out 1 700 armed soldiers to assist in maintaining order and the Mayor had the good sense to decree, "I forbid the sale of alcohol and the Federal Troops, the members of the Regular Police Force and all Special Police Officers have been authorized by me to kill any and all persons found engaged in looting or in the commission of any other crime." Looters actually were shot with a very salutary effect. This is an example of the immediate stern measures which such circumstances require and which those in authority must be brave enough to take The earthquake occurred at dawn before most citizens were up and casualties were largely from the immediate fall of buildings or from burning of those trapped. Due to the early adequate police measures, rescue, evacuation and fire fighting began immediately hampered by broken water mains and rubble-filled streets. Treatment of casualties is not an important part of the story of this disaster which took place before blood transfusions and antibiotics before abdominal exploration for injury

ter nearby, all residents and at least half of the faculty and student body had had recent war service. The treatment here was in contrast to another hospital where the staff took Lysol baths to keep from "catching" gas gangrene.

Most of the serious injuries occurred within 500 to 1,500 feet of the blast but as far as a mile away there were lacerations, contusions abrasions and ruptured eardrums. Deaths were due largely to combinations of blast, fire, dismemberment from flying debris and drowning from a miniature tidal wave occasioned by explosion of the second ship There were very few severe burns, most injuries being from secondary mechanical effects of blast. An analysis of 3 000 casualties showed these to be the most characteristic findings (1) multiplicity of injuries; (2) frequency of punctate wounds from imbedded glass fragments, especially on the head and extremities, (3) all types of fractures (4) primary blast effects as eardrum rupture in a third of the cases plus transient hematemesis or hemoptysis and urinary retention.

The university hospital was cleared of ambulatory patients, casualties were put in bed and groups of specialists began to circulate to sort the patients. Without rigid control, usage of drugs and supplies becomes excessive and recognized policy tends to be violated. Such was the case in this disaster where three proven cases of gas gangrene were diagnosed and as a result all patients with wounds from which anaerobic organisms were isolated were given gas gangrene antitoxin at a cost of $10 000 Another point of interest is that although individual doses of only 5,000 units of penicillin were given, this disaster practically exhausted the national supply of the drug This certainly indicates the necessity for stockpiling. Blood was obtained from a fairly distant large city thus eliminating the blood

bank problem in the disaster area. This presupposes the adequacy of communication and transportation facilities.

Only 50 patients died after hospitalization 14 of these at the university hospital nine of these in the first 24 hours. Eight of these nine early deaths were due to head injuries. Among the 300 patients admitted to the university hospital, there were seven instances of clinical gas gangrene but no deaths resulted. Secondary wound infection was not a major problem as had been anticipated.

In 1958 a school fire claimed the lives of 89 children, three teachers and generated 300 casualties most of whom were admitted to a 322 bed hospital within an hour The smooth functioning of this hospital was widely acclaimed, credit being partly due to a pre-planned scheme of action in disaster There were rough points most of which have been mentioned before but in this instance were as follows

1 The tagging system gave insufficient information as to patient-condtion so that delay resulted from necessity for reevaluation and examination
2. The auto and human traffic which converged on the hospital was a serious hindrance and some doctors had to park four or five blocks away because of the traffic jam.
3 The team concept was difficult to enforce because everybody wanted to help and everyone wants to be team captain. Doctors with special skills must be used to the best advantage. In this emergency, military specialists were sent thousands of miles to assist in burn treatment.
4. After the first few days when the team concept was set aside and doctors began to take charge of individual cases there was a multiplicity of orders which complicated the administrative and nursing

load, breaking up any attempt at "routine" management.

5 The value of a disaster plan which has been tested repeatedly cannot be overemphasized.

A Tornado

Some hospitals have disaster plans, fewer have tested their plans but an even smaller number have been built with the flow pattern designed for handling mass casualties. One such hospital was called upon to admit 175 tornado casualties in a matter of a few hours, the design and prior planning paying great dividends. One key to success was a vigorous triage officer who was thus described in a newspaper article, "He had all the force and authority of a sergeant major He dispatched each victim to proper care areas—emergency first-aid, observation, surgery obstetrics or the morgue. Between cases he barked orders to doctors and nurses, consoled bereaved families, and perked up weary workers with a reassuring smile. Backing him up were everyone from telephone operators and orderlies to head nurses and doctors who made the big hospital hum far into the night." The following things were learned from this disaster

1. The theory that disaster is a series of individual emergencies was corroborated. These individual catastrophies happen almost at the same time but the more nearly a person can be used in his normal hospital capacity, the smoother the functional result.
2. Speed is not as important as the proper handling of each step in the process.
3. While the disaster may occur in a minute, the first patients do not arrive from the disaster area immediately even when it is close at hand.
4. It was learned that a proper physical layout, suit

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3 While the disaster may occur in a minute, the first patients do not arrive from the disaster area immediately even when it is close at hand.

4 It was learned that a proper physical layout, suit

able sorting of patients, an abundance of properly trained and disciplined personnel, adequate equipment and supplies plus assurance to those wanting information, are the basic essential ingredients in successful handling of a disaster

5 Supply sources can and do assume the initiative in re-supply and issue so that time is not wasted in preparing orders and requisitions.

Up to this point the reports on management of disasters have been made by those intimately concerned and the rose-colored glasses are obvious in the records Nothing really bad happened and if it did, it obviously was unavoidable. Even so, many interesting points emerged and have been stressed herein Unfortunately a tornado which struck a large metropolitan area of 250 000 population in late afternoon, generating 1,500 casualties, has been studied extensively by an outside team of investigators and most of the mistakes which could have been imagined were made and publicized. Much rationalization has been done by those concerned but still this disaster represents a fiasco which should not be allowed to recur The mistakes made will be recounted not to add criticism but to point out the needlessness of most of them and to show how simple planning and testing can obivate most.

The tornado struck at 4 30 PM, and in the city under discussion it totally destroyed 250 dwellings and damaged 2,200 others. About 12,000 persons were rendered homeless 85 were killed outright, 490 were injured severely enough to require hospitalization and over 1,000 incurred minor injuries. Seventeen hospitals shared the load of these 490 casualties albeit very inequitably

Alert Warning

There was no advance warning and the police were

notified fragmentarily so that only after the fact was it realized that a real emergency existed. No general alarm was sent out through official channels. Many citizens were alerted only by the crescendo of noise of the approaching tornado Police cars were sent to survey and appraise before an alarm was sounded and by that time the electric power was off and the switchboards were so jammed that telephonic notification was impossible. Fortunately the utility companies were notified in time to pull the master switches, thus averting a fire from the live wires. Some hospitals received as much as 30 minutes advance warning but most were notified by the arrival of the first walking wounded or by the sirens of the ambulances.

Rescue and First-Aid

The poor judgment of people in a panic state is exemplified by the fact that although all casualties were evacuated from the area of destruction within two hours, less than 10 per cent of the casualties were given any first aid. Fractures were not splinted, wounds were not covered, bleeding was not controlled and the few tourniquets applied were as is usually the case, inadequately used. Some doctors went to the disaster area to give first-aid and some even set up an aid station but most casualties passed them by in the rush for the hospital. Doctors in the disaster area saw little shock but many cases later needed blood partly because of the passage of time, because wounds were not dressed nor were fractures splinted and because vehicles evacuated them at high speed over rough roads and cobblestones There was no organized attempt at triage or at direction of casualties to specific hospitals One doctor remembers searching for something to use as a tourniquet, applying an electric appliance cord

for this purpose and only later realizing that he had left the electric iron still attached

Evacuation and Traffic Control

All manner of vehicles were rushed to the scene and patients were loaded in, lying on doors or bed springs or sitting Drivers were told only to head for the nearest hospital. Municipal ambulance drivers went to the one hospital where they were accustomed to take accident cases No police control was exercised and no road blocks established. Vehicles sped along at 40 to 60 miles per hour, sightseers joined the throng and even some hot rodders entered the race. In the city area many volunteer directors of traffic appeared sometimes as many as five individuals trying to direct traffic on one corner It was reported that one man became so obsessed with the necessity to direct traffic that he exercised this function in every noon hour for the next several weeks. There was no attempt at traffic control at the hospitals and the closest one was quickly overrun, vehicles parking and unloading at four entrances This hospital cared for many minor walking injuries and serious cases could not get near the doors because of the traffic jam. At one hospital which was overrun with minor cases and visitors casualties were unloaded in the yard. Later doctors went out and climbed through ambulances to give treatment there.

Medical Care

No special plan was followed so that in one hospital the minor cases were placed near the admission area and shock cases had to be carried to the extreme other side of the building. Some hospitals made no attempt to sort patients but admitted through as many as four entrances Others tried to set up triage points but additional doors

were opened to vitiate the attempt. No rosters or locator systems were kept and visitors wandered through looking for relatives. One hospital had a triage plan calling for use of a certain entrance but the staff forgot to use the plan. One hospital designated non-surgeons as triage officers on the theory that all surgeons were needed in the operating room Too many people assumed responsibility for triage wasting time climbing through vehicles in the traffic jam. Dead were evacuated indiscriminately with the injured and at one hospital the dead were taken to the admission room, later to be moved. Lightly injured out numbered the serious cases two to one, hindering the medical effort.

The neurosurgeons apparently were alone in their ef forts to segregate patients and regulate the hospital to which head injuries should go There seemed to be a widespread feeling that no hospital should send patients to another hospital. When ambulance drivers attempted to exert some control, the hospital professional and ad ministrative authorities resented this and stated that the hospital would take all comers even if they had to stack them on the roof. It is interesting that this attitude and the total lack of medical regulating control resulted in the seven hospitals in this city receiving the following numbers of casualties 3 10 8, 168 27 103 and 55.

Shock and Resuscitation

There was great impetus to draw blood but relatively little to use it. As a result local agencies drew 1,120 units of blood, almost none of which was used and because of lack of refrigeration, it subsequently was converted to gamma globulin. In addition there were available 159 more units of blood, 126 units of plasma in stock and 1,014 units of plasma from other sources. Actually less

than one unit per casualty in shock was used and the feeling seemed to be that trauma cases do best with little blood replacement. Patients were operated upon while in shock, without replacement and at least one died of this. Medical personnel were unfamiliar with plasma volume expanders.

Pattern of Injury and Treatment Results

Most of the dead had skull fractures and among the casualties there were 77 head injuries and skull fractures. There were about 160 fractures mostly of long bones, 28 eye injuries mostly from foreign bodies, nine ruptured kidneys, six ruptured spleens, five burns and 147 major lacerations. Only five surgeons adequately debrided wounds, accounting for only 23 cases. All the other major lacerations were treated by primary suture either without any debridement or with an inadequate attempt. The doctors involved claim only a 10 per cent incidence of wound infection but house officers admit to at least a 50 per cent incidence, stating that the wounds exuded pus and sticks and stones for a period of over six weeks. In the mad rush to suture wounds, doctors did this procedure in ambulances and in one hospital with an uncompleted new wing without electricity and with patients on mattresses on the floor, doctors got down on the floor to suture wounds by flashlight. This mania to suture wounds is incomprehensible.

Long bone fractures were treated mainly by debridement, primary closure and plaster cast so that 30 to 35 cases required operative repair within the next six months, an incidence of about one in three. One hospital routinely used local sulfonamides and primary closure. One hospital discarded asepsis early using tap water to wash instruments and passing instruments from table to table.

The recitation of mistakes made is a long one and could

be extended further but in summary it can be said that there were no plans no organization, no alert, no first aid, no traffic control, no regulation of hospital admission, no triage, no standardization of treatment and little attempt to follow established principles such as blood volume replacement and wound debridement. In spite of later rationalization, this remains as a demonstration of what should be avoided at all costs. It is important that we be medically prepared to meet disasters of small magnitude which furnish the experience and background from which we plan for major catastrophies. The importance of this is emphasized by Major General Silas B Hays, Surgeon General of the Army in the journal of the American Medical Association for 20 September 1958 when he said, "Why is it desirable to improve our medical preparedness? Have we not always handled our medical emergencies in both peace and war reasonably well? The answers to these questions are important. If we are already doing all right then let us forget the whole thing. On the war combat side the answer is obvious things have changed and are changing rapidly Newer weapons of war can inflict casualties on a scale previously impossible On the natural disaster side the answer is not so obvious, but it is clear We have not always done a good job in handling medical emergencies. Advances in medical knowledge in the last quarter-century have frequently not been put to use. It is important that the medical profession realize this and further realize that a peacetime medical emergency can occur any place. We have not learned how to prevent bus train, or airplane crashes, hurricanes, tornadoes, floods, or fires If the local medical community will prepare itself to cope adequately with these, it will have gone a long way toward preparing itself for a wartime disaster"

IX

LESSONS LEARNED FROM SIMULATED CASUALTY EXERCISES

It is essential that every hospital have an emergency plan and that all individuals be trained in their role but this still is not enough All hospitals should test their plan periodically by means of a simulated casualty exercise made as nearly realistic as possible. Not only does this show up deficiencies but when the plan works well, it gives confidence to those concerned. It has been said that we learn by doing we succeed only by having sometime failed. The ability to profit from mistakes is the mark of the mature person.

Actually, there are two aspects of the emergency plan, both of which require consideration and emphasis. One aspect is to plan for the reception and treatment of large numbers of patients in a short period of time. The other aspect is to plan for evacuation of the hospital itself in case of disaster, such as fire or flood. Both must be planned and tested.

It is extremely difficult to simulate a casualty exercise realistically for several reasons

1 Supplies cannot be wasted wholesale in a test exer cise and this means that realism is sacrificed and experience is lost. For example sterile packages cannot be violated unless reconstitution is possible. Band ages cannot be used unless they can be re-wound satisfactorily, intravenous needles cannot actually

be inserted because of the waste of fluids and other equipment. Many other examples could be enumerated.

2. Mock casualties can be obtained readily but will not know how to answer questions of triage officers and others. This may not seem important but simply carrying a "body" on a litter does not pose the problems of an actual patient.
3. This is compensated for by a diagnosis tag tied to the simulated casualty. This oversimplifies triage of patients because it is so easy to read the tag and not examine the "body." Thus the diagnosis is made too easily and the time factor is not realistic. The triage officer may read tags much more rapidly than he and his helpers could examine, diagnose, tag, give emergency treatment, make the roster and evacuate the "body."
4. The time factor is important in other regards also since we must allow the time required for a bottle of blood to run in if transfusion is simulated and we must allow realistic time periods for each operation simulated. There may be a tendency to "cheat" on these periods and thus a falsely optimistic impression is gained.
5. It is difficult to get all personnel to "play the game" seriously. Litter-bearers may "goof off" when they get tired of seeing the surgical team sitting down to wait out the simulated operation time, et cetera. Often the people of lesser skills may not see the importance of realism or may be easily satisfied after short performance. Actually, there is no reason why simulated casualties cannot walk along beside the litter provided that the bearers walk as slowly as if they really carried a patient.

It is important to remember that situations should be as "real" as possible, keeping accurate count of supplies that would have been used and time periods that would have elapsed so that an accurate end result is attained

"Operation Rebound," Houston, Texas

"Operation Rebound" was an exercise designed to test the ability of the communities of the Gulf Coast region south of Houston, Texas, to provide medical support in the event of a disaster which would destroy completely the hospital and medical facilities within the city and environs It involved also a field trial of the 200-bed FCDA emergency hospital by civilian physicians, nurses and paramedical personnel. The theoretical problem postulated nuclear destruction of a zone of ten miles radius from the downtown area, destroying medical facilities and personnel. It was presumed that 100,000 persons on the periphery survived and that 500 casualties were transported for medical care along major highways. About 3,000 persons participated in this test exercise. Each participating medical school had one of the 200-bed FCDA hospitals for test. Medical students were used to simulate patients and older scouts were litter-bears.

An early observation was that the 200-bed hospital was so securely packed that it was difficult to get the many boxes and crates opened. Next, it was noted that the hospital was not functionally packed so that repacking according to area of usage was needed. When the hospital was functionally packed with color coding of the boxes to indicate area or hospital department, it was possible to unload, unpack, set up in a suitable building and receive patients within an hour It is essential that staff and technicians be familiar with the hospital apparatus in order to set it up efficiently and correctly Breakage and waste

of time will accompany emergency setup without trial runs.

The Houston exercise again showed that communications tended to break down repeatedly resulting in delays and lack of overall supervision and coordination. This observation is made at every test and in every disaster but yet the problem has not been effectually solved. The test further showed the lack of authoritarian control which has been mentioned previously as a basic fault. People are reluctant to give orders or to accept them. As a result of the Houston test, Olson posed the following questions for solution.

1 Can the existing FCDA hospital units be modified to make them more readily utilizable especially from the standpoint of functional packing?
2. Can existing equipment deficiencies be remedied?
3 How are medical, nursing and lay groups to be properly trained in setting up and utilization of these hospitals?
4. How can the civilian groups required to man the hospitals be organized and trained to recognize and obey the authority of those in command?
5 How shall those in command learn the multiple requirements for establishing these units on an emergency basis?

Exercise "Fire Drill," Brooke U S Army Hospital

Exercise "Fire Drill" was designed to test the ability of Brooke U S Army Hospital to accept and treat 1,000 simulated casualties. Geographically Brooke is essentially two separate general hospitals and an administrative headquarters. Duty personnel are about half military and half civilian, 75 per cent living off post in the civilian community The emergency operations plan is divided into

three phases phase 1, two hours, 100 admissions phase 2, six hours, 500 admissions, 12 hours, 1 000 admissions, phase 3, 24 hours, 2,000 admissions, 36 hours 3,500 ad missions Pyramidal system of notification of personnel is used. Twenty five operating teams are provided from duty personnel Soldiers were used as simulated casual ties, experienced soldier litter bearers were used and the Chief of Surgery acted as triage officer The test showed that even experienced litter bearers wear out quickly and four man teams were necessary Even so, gloves were required for hand protection. It was found that each operat ing pavillion could do 100 major procedures before calling for additional supplies if austere use was employed. The test showed that the Brooke Emergency Plan was feasible and workable with the following three main deficiencies being noted

1 Communications were unsatisfactory both inside and outside the hospital, between wards and operating pavillions as well as between buildings
2. Supplies were insufficient, and austere usage was difficult to attain and maintain. Distribution should be in balanced package units as much as possible and should be for only a few hours instead of for a day to decrease wastage. Certain emergency items as tracheotomy sets dextran and dressing trays should be centrally controlled and allocated.
3 Litter bearers were difficult to obtain and to keep on the job They need frequent rest periods glove protection and strict continued supervision

Other Hospital Tests

One large hospital staffed by individuals many of whom had battle experience staged a test exercise to admit 200 patients and simulate treatment. Individuals were trained

in their duties and an extensive system of signs and labels made everything easy to find. This test went off like clock work with little confusion and few deficiencies. However not a month later an airplane crash nearby engendered 16 patients and their admission to this same hospital was attended by chaos and confusion. The moral of this story is that "simulated" exercises always are just that, realism being difficult if not impossible to attain. The hysteria of duty personnel, patients and outsiders cannot be simulated but exerts a very disrupting influence in an actual emergency

The other aspect of the Emergency Plan was tested by a civilian hospital in a medium-sized community where a test evacuation moved 270 simulated patients, evacuating personnel, critical supplies and equipment to an Evacuation Hospital 20 miles away in 88 minutes. The hospital itself was cleared of patients, personnel and supplies in 45 minutes. Such tests always are fallacious because here the elevators as well as the stairs, were used and simulated patients can be moved much more readily than sick patients. Previous estimate in this test had postulated a minimum of two hours, which might be quite accurate in an actual disaster with power and traffic disruption. One point of interest was the observation that women can carry patients without too much difficulty with the patient in a straight chair tilting it back with one bearer lifting the back of the chair and the other the front legs.

X
SURGICAL COMPROMISES REQUIRED IN MASS CASUALTY CARE

From what has been said thus far, it must be abundantly clear that we will indeed face a difficult problem in medical care should large masses of casualties be generated by whatever means. It must be evident also that the degree of our distress will be in direct proportion to the size of the load as compared with availabilities of personnel, material and time. It is perfectly obvious, therefore, that we will be operating upon a sliding scale at one end of which will be a situation with which we can cope without difficulty while at the other extreme will be a set of circumstances which we cannot encompass at all. In between will be all possible variations of circumstances and capabilities. The very nature of the problem, then, makes it difficult to make definitive statements because of these multiple variables and imponderables Not only must we face huge case loads with reduced capabilities for treatment but we must anticipate that patients will reach medical care later after injury so that the "golden period" may long since have passed. Most disagreements in discussion of care of mass casualties arise because of failure accurately to define our terms of reference. Consequently, in this discussion it has been decided to outline first, under each category the best treatment under optimal conditions and then to discuss the compromises which must be made under austere and less favorable circumstances.

Self Help, First Aid and Rescue

Little, if any improvement has been made in this phase of treatment of combat wounds in the past one hundred years, most of the startling developments and improvements having been in the field of definitive care. These points are emphasized by the records showing a decrease in those dying of wounds (DOW) to 2.4 per cent in Korea from approximately 22 per cent in the Crimean War as compared with the killed in action (KIA) figure of 25 per cent which has remained almost constant. Since it has been pointed out that most of the early deaths are from uncontrolled hemorrhage or obstructed airway it seems obvious that earlier pickup of casualties should be a fruitful field for improvement. Thus, the time factor is of great importance. Unfortunately in a mass disaster the time lag may be much greater than in combat and thus we may see an even higher KIA figure.

Self help first-aid and rescue are functions of non-medical personnel, highlighting the statement that all individuals should be trained to control hemorrhage, apply dressings apply emergency splints, handle the injured, give artificial respiration and give emergency care to certain special wounds such as sucking wounds of the chest and jaw injuries which cause respiratory obstruction.

Control of hemorrhage depends on knowledge of arterial pressure points how to apply a pressure dressing and how and when to use a tourniquet. Use of pressure points is a self help measure but occasionally an individual may apply his own pressure dressing or tourniquet. This ability may be life saving

Maintenance of airway depends on knowledge of how

to replace displaced tissues by a Barton dressing, position an unconscious patient pull the tongue forward, apply airway to-airway artificial respiration establish a tracheotomy or dress a sucking wound of the chest. With the repeated changes in type of artificial respiration taught in the last few years, it is imperative that the air way to-airway method which has been decided upon be demonstrated and taught to large groups of people at the earliest moment practicable Tracheotomy remains as an infrequently needed procedure and probably when needed most, cannot be accomplished in time Lt Colonel Ziperman evaluated the Sierra Shelden tracheotome as a do-it yourself instrument and even with the 3 per cent posterior perforation as the only major accident, the fact remains that the instrument and tubes simply will not be sufficiently available.

Emergency splinting is difficult to put across as a must in first-aid prior to movement of the patient. It should be emphasized that splinting is good treatment for soft tissue injuries, as well as for fractures and that a massive dressing serves the purpose admirably Absence of fancy apparatus is no excuse and it should be taught that the good leg makes an excellent splint if both legs are tied together A simple Velpeau type of bandage to hold the arm to the chest wall or even a triangular bandage sling is suitable for upper extremity injuries. Tree limbs pieces of lumber broom sticks rolled news papers pillows, rifles and a hundred and one other objects make good emergency splints In disaster situations it is especially important to apply immobilization splints because such patients have a lesser tendency to go into shock and this splinting may be all the treatment the patient will get for many many hours

Wound dressing is essential to prevent further contamination, to lessen pain, to hold parts in apposition, to stop hemorrhage and to prevent further damage. The multiple-tailed military dressing is excellent for protection and compression but in its absence a triangle of cloth can be made to serve for any region or purpose. Much time has been wasted in first-aid classes in teaching the use of roller bandages in *spiral reverse* and other fancy forms whereas the student need only learn to protect and immobilize the various body regions with the multiple-potential triangular bandage.

Handling of patients is based on the assumption that a quick physical examination has been done hemorrhage has been controlled, wounds have been splinted or dressed and airway is established. Only then is it safe to move the patient and even here it is essential not to damage the individual who has a fractured spine or neck. This has been used to frighten lay students to the point where they may consider all wounded as litter cases. If the patient can move without pain, has no obvious deformity and is conscious, spine and neck fractures can be ruled out as well as possible. Unconscious patients should be moved with caution as though the neck or spine might be injured. *For litter carry the unconscious* patient does best with face down, head turned to the side, tongue pulled forward and one hip and knee flexed to give stability

Even rescue work is largely in non-medical hands, patients being transported by all sorts of conveyances. If there has been adequate and proper first-aid, the patient will not be further damaged by transport, realizing that movement of the patient is not in his best interests but is a compromise if he is to reach a treatment point.

Aid Station Care

It is difficult to distinguish clearly between first aid and the resuscitation given at the aid station because the latter is simply a continuation of the former with more adequate facilities being at hand. Any or all of the first aid procedures may be carried out at the aid station if they have not previously been completed. Aid stations are the first medical facility and they should perform the following functions

1. Receive casualties from any and all sources.
2. Sort and classify casualties according to nature and severity of wounds. This is the initial triage point.
3. Decontaminate casualties if nuclear or chemical agents enter the picture.
4. Administer first aid if this has not been done previously and complete or revise the earlier attempts. This initial professional care includes definitive care for minor wounds which need go no further
5. Give blood, plasma or plasma volume expanders after blood loss is stopped or in other cases if definitive care is available soon.
6. Relieve pain with morphine or a good substitute remembering that barbiturates may make the patient unmanageable and that morphine in small doses intravenously is preferable to larger doses intramuscularly Patients in shock do not absorb drugs from the intramuscular route until shock is overcome, may then absorb rapidly and thereby may develop morphine poisoning. It should be emphasized that accident cases have the anesthesia of trauma and may have little pain. Proper first aid in itself relieves pain. The use of morphine is grossly overdone ordinarily

7 Give tetanus toxoid booster shots and start anti biotic administration within the limitations of supply and demand.

8 Prepare, maintain and transmit appropriate medical records and reports. These need not be wordy and voluminous but should state what was found, what was done and what drugs were administered. Over dosage often follows failure to note drugs and dosages given.

9 Maintain medical supply levels for the local station and try to furnish necessities to rescue workers who go forward to find casualties

10 Later as circumstances warrant, act as a follow up point for continued care, dressing change, drug administration and record completion.

It cannot be repeated too often that in a really desperate situation, self help and first aid may constitute the sum total of medical care and it, therefore, behooves us to make every effort to see that this important aspect is covered by wide and repeated training of as many persons as possible.

Debridement of Wounds

In contemplating the medical management of mass casualties, the problem of care of the injured seems to be almost overwhelming Obviously intelligent compromises will have to be made in accordance with the patient load, the available staff supplies and equipment. To approach this subject, it seems wise to review the accepted principles of wound care and to apply them with compromises required for the care of mass casualties.

Optimal Wound Care

The control of hemorrhage is given first priority Hem-

orrhage may be controlled by digital pressure, elevation, packing, clamping vessels or tourniquet, but preferably by a pressure dressing. Once a tourniquet is applied, it should be left in place until removed by a physician with adequate blood or plasma expander necessary to resuscitate the patient. If no hemorrhage exists, a simple dressing should be applied and a splint if indicated. If the severity of the wound warrants, a small dose of mor phine may be given preferably intravenously, since the patient may be in shock and not absorb the morphine if given intramuscularly or subcutaneously

Shock should be treated in accordance with existing principles by the use of blood or plasma expanders such as dextran. Other adjuvant measures as head-down position and the use of oxygen should be utilized and the patient kept warm enough to prevent shivering

Antibiotics should be given as soon as possible and just as morphine is given intravenously, the antibiotics also should be given intravenously for rapid dissemina tion and absorption. Tetanus toxoid or tetanus anti toxin should be given as soon as time permits.

Complete and careful examination for wounds of en trance and exit under a good light is necessary to de- termine the extent of damage Determination and re- cording of neurological and vascular damage is impor tant. Following first aid and resuscitative measures, the area of injury should be X rayed as an aid to diagnosis and localization of foreign bodies

General Principles of Debridement

Surgical debridement may be defined as a procedure for the removal of devitalized tissue, blood clots foreign bodies and for control of hemorrhage. First the wounded area is shaved, scrubbed and irrigated with sterile water

or saline. Detergents containing hexachlorophene are excellent for shaving, cleansing and preparation for surgery

Bold, adequate incisions are made in the long axis of extremeties or in the natural skin lines where applicable. Skin is preserved where possible but an adequate exposure with a view of all the wound under a good light is necessary Frequent irrigations with sterile normal saline help to cleanse the field and identify structures. All devitalized tissue must be excised and foreign bodies and dirty detached bone fragments removed. Small foreign bodies difficult to reach in non-vital areas may be left in place. One should be gentle as in any other surgical procedure and exercise care of vital structures. Hemostasis is important. Small vessels may be ligated with with fine silk or catgut. Because of the high velocity missiles used on the battlefield, the lag time from wounding to surgery and necessity for evacuation, military directives require that battlefield wounds be left open except for closure of joints and coverage of vital structures such as bone, nerve, tendon and vessels. While wounds of the scalp face, neck and scrotum usually may be closed primarily it is safer following debridement, to leave all other wounds open for delayed closure Large dependent cavities should be counterdrained. The wound then is covered with a dry, fine mesh gauze with slight pressure applied but no packing Immobilization will depend upon the severity of the wound, but if a cast is applied, the cast and underlying padding should be cut through to the skin.

Wounds over 48 hours are managed in accordance with the same principles except in certain cases of established infection and cellulitis with toxicity The general condition of the patient may permit only drainage of

hematomas and abscesses to be done while the patient's general condition is improved with antibiotics, fluids and transfusions until radical surgery can be done Such postponement does not apply in cases of clostridial myositis

Debridement of Specific Tissues

Skin. Adequate incision and excision of the skin is necessary but conservation should be practiced, especially on the hand, foot, forearm and face. Longitudinal incisions should be utilized on extremities except in in stances where natural skin lines can be followed. At joints, a modified Z or S type incision should be employed. Counterincision should be used for drainage as indicated. The skin is left unsutured except where necessary to cover vital structures as bone, nerve, tendon and vessels and the scalp face neck and scrotum where the skin, because of its excellent blood supply, usually can be closed safely

Subcutaneous Tissue All devitalized subcutaneous tissue is excised.

Fascia. It is difficult to determine viability of fascia but, because of its poor blood supply, all dirty, frayed fascia should be excised Fascia must be incised adequately and widely for drainage or exposure and to allow room for the swelling which will follow The lines of the fibers should be followed. Fasciotomy is probably more often indicated than practiced, especially in the presence of contusion, crush, hematomas and commonly in the limb which has experienced a prolonged period of is chemia with return of blood supply Such limbs tend to swell within their fascial compartments and if fasciotomy is not done may result in irreversible muscle changes.

Muscle Muscle is the most important and most diffi cult tissue to debride There is the constant danger of

clostridial myositis to be considered. Normal muscle may be identified by (1) consistency (2) contractility, (3) color, and (4) ability to bleed. One must be thorough since absorption of the products of inadequately debrided muscle and the resultant infection may overload kidneys already damaged by shock and result in an anuric death. Most dangerous are wounds of the large muscles of the thigh, buttocks and back. It must be remembered that muscle is more widely damaged than fascia and, therefore, generous incision of normal fascia often is needed to expose all devitalized muscle. Inexperienced operators always are too timid in this regard.

Bone Attached fragments of bone should be left in place and conservation practiced, avoiding creating a defect but loose, dirty displaced fragments in the wound must be removed. The bone should be reduced manually and a cast applied to immobilize and the cast cut through to the skin.

Joints. Early complete debridement of joints with removal of detached bone and cartilage fragments and all foreign bodies is very important. The joint then is irrigated thoroughly antibiotics placed in the joint space the capsule closed and immobilization practiced as indicated.

Tendon. In avulsed, macerating wounds tendons are debrided conservatively and the ends buried or covered for protection until repaired by delayed suture Primary tendon repair may be practiced in the presence of noncontaminated lacerated wounds depending on the tendon involved.

Nerves Careful examination and recording of findings is extremely important in peripheral nerve injuries. Damaged nerves like tendons, must be debrided conservatively and covered. Some place a small suture in

the neurolemma not as a marker but to anchor the end of the nerve to prevent retraction.

Vessels Vessels are debrided carefully and occasionally a simple clean laceration can be repaired by lateral suture. Larger defects are repaired by anastomosis, autogenous vein grafts, homologous artery grafts and occasionally by the use of plastic prostheses. No anticoagulants are used and the vessel must be covered for nutrition, preferably by muscle or adipose tissue. Fascia is not a satisfactory covering

Closure

Ideally delayed primary closure is done in clean wounds four to six days after debridement. In caring for mass casualties it is doubtful if the initial debridement will be done on many within four days

Compromises in the Care of Mass Casualties

The number of injured requiring treatment is a matter of guesswork. If the type of bomb used and circumstances were the same as at Hiroshima, we might expect one fourth of the population to need medical care with 70 per cent of the injured having mechanical wounds, in addition to 65 to 85 per cent with burns, and 30 per cent with some irradiation. With the development of thermonuclear devices with variations in yield, with the differences in geographical situations and the amount of shielding afforded individuals the percentages and types of combinations of injuries may be totally different from any we have estimated. Again, if the situation were similar to Hiroshima, we might expect the 70 per cent with mechanical injuries to have injuries consisting of approximately 40 per cent lacerations 10 per cent fractures and 50 per cent contusions For planning purposes

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we might assume that one third of those injured will be walking wounded, one third moderately injured, and one third seriously injured. Care probably will be available for the first two groups Many of the walking wounded will be able to give themselves self-care or be helped by a buddy The second group will cause most of the load on surgical facilities Into the seriously injured group will fall cases with abdominal and thoracic wounds because there will not be time, facilities, supplies or equipment to care for them.

In the immediate area of the bomb it is expected that death will come from translation, burns and severe wounds. While a cellar ditch or other depression may protect from burn and mechanical injury there is still radiation to be considered. It is expected that missiles in an area where man might survive fatal burns will be of the low velocity type. It is doubtful that gravel and other debris on the ground at that distance from the bomb will cause much damage. Glass will probably cause some cuts but probably not of a serious nature. In other words, in an area where man might survive severe burns and lethal irradiation, it is expected that mechanical wounds will be of a moderate nature. The variations in nuclear weapons make such a guess just that. Surgery will be necessary to debride wounds, remove foreign bodies and control hemorrhage even though the patient may die at a later date of unsuspected irradiation injury

After debridement, all wounds will be left open with vital structures as nerve, tendon, bone and vessel and organs as the trachea, esophagus and testis covered with enough tissue for protection. If time equipment and personnel are to be used to do any phase of a debridement, it should be completed. The mere unroofing of

tunnels, incising deep wounds for drainage or simply opening fascia over a penetrating wound will not suffice. Incision for drainage might actually cause death by dislodging a clot which was controlling bleeding from a damaged vessel. For this and other reasons, incomplete debridement is worse than no treatment at all. Infection will be a major problem. Antibiotics given prophylactically will delay the onset of infection but not prevent or decrease it. Tetaus will carry a high mortality unless proper immunization is employed.

Paramedical personnel as dentists, nurses, veterinarians and others will have to serve as surgical assistants, give anesthesia and assist with resuscitation. It is unfair to expect them to do acutal debridement in unfamiliar fields but it has been shown that they can do simple debridement with one trained surgeon supervising as many as seven tables.

The shortage of trained anesthetists will be a problem. Some nurses, dentists and other physicians can give drop ether or chloroform, but it is expected that much of the debridement can be done under local infiltration or field block. Nurses and dentists can be of assistance in giving such blocks. Minimum strength solutions as 0.25 to 0.50 per cent procaine will suffice.

The most use also will have to be made of supplies. Linen shortage no doubt will occur. Debridement can be done with one towel, if necessary. Perhaps some form of plastic drape which can be washed and boiled or simply washed and re-used may be practical. Instruments can be washed, boiled and re-used. If a shortage of gauze sponges exists, they can be washed, wrung out and used again. Possibly a cellulose or plastic sponge would be more practical for re-use. No doubt irrigation solution will be in short supply especially saline. In

such case, sterile water or unsterile tap water can be used if necessary

In order to do the most good for the greatest number of people, the following is suggested for debridement in the order listed.

Priority 1 Wounds requiring debridement as a life-saving procedure *as debridement and tracheotomy for* relief of respiratory obstruction, debridment for control of hemorrhage or to control open chest wounds.

Priority 2 Severe, macerated wounds requiring simple amputation or vascular wounds controlled by tourniquet which require debridement, ligation of the vessel and removal of the tourniquet. Pulsating hematomas should be left intact.

Priority 3 Soft tissue wounds most important of which are wounds of the high, buttocks and back.

Priority 4 Simple wounds of the walking wounded which may have been given simple first aid and returned to work but which may eventually require surgical at tention.

Treatment of Burns

It has been estimated that 65 to 85 per cent of the injured in an atomic disaster may have some burn. Many of these will have additional mechanical and irradiation injury The numbers of burns will vary with the thermal yield of the nuclear device used and the situation under which it is employed. It does not take a thermonuclear weapon to produce enough burns to cripple the medical facilities of a good-sized city An industrial explosion or a large fire can very effectively overload even the best facilities Even six to eight burn patients can disrupt a well-staffed, well-equipped institution. Realizing this makes the burn problem in mass casualty care seem

overwhelming Obviously compromises in therapy wi have to be made. Such compromises can be made i accordance with the burn load, the available staff an equipment. In order to decide on what compromis will be necessary, it is probably wise to review the pre ently accepted concepts of treatment of burns and the apply those concepts as intelligently as possible wi compromises required for treating massive numbers burns.

Presently Accepted Concepts of Treatment

Burn care may be divided into two phases (1) su portive or systemic care and (2) local care of the bur

Supportive Care With the burn there is destructi of tissue. In the immediate area intense vasodilatati results in a temporary loss of fluid in the form of edem There is also a permanent loss of fluid from the burn area in the form of blisters and weeping from the burn surface. Red blood cell destruction also occurs from t burn itself The fluids lost are similar to plasma in ele rolyte and protein composition. The fluids lost into a from the burned area are at the expense of fluid fro unburned tissues and the plasma. This mechanism withdrawing fluids from normal tissues and the plasn is limited and unless treatment is instituted, circulato collapse and death will occur It is for this reason th the supportive phase of therapy is primary and most i portant.

No attempt is made to measure the amount of collo and electrolytes lost but both are replaced according the needs of the patient. The amount of fluids giv and the rate given are determined by the clinical spouse of the patient. One criterion of adequate repla ment is a urinary output of 30 to 50 cc. per hour T

fluid needs of such patients are estimated by various formulas such as the Evans formula or the Surgical Research Unit version of the formula. This formula calls for replacement of colloids and electrolytes according to degree and percentage of body burn. The per cent of surface burned can readily be estimated by the "rule of nines" By this method an approximate measurement of the percentage of burned surface can be estimated.

Head and trunk	9%
Anterior trunk	18
Posterior trunk	18
Upper limbs (9% x 2)	18
Lower limbs (18% x 2)	36
Genitalia and perineum	1
	100%

Another method of estimating burned area is to remember that the palmar surface of the patient's hand equals approximately one per cent of his body surface.

With the per cent of burn surface calculated, this per cent is used for figuring fluids needs up to 50 per cent. Body burns of over 50 per cent surface area still are calculated as 50 per cent burns when estimating fluid replacement.

Colloid needs, consisting of plasma, blood, serum albumin and plasma expanders, are figured at 0.5 cc. x kilo body weight x per cent body surface burned. Electrolyte needs of normal saline or balanced salt solutions are estimated at 1.5 cc. x kilo body weight x per cent body surface burned. An additional 2000 cc. of glucose in water is added for urinary and insensible water loss The formula may be expressed as follows

Colloid, 0.5 cc. x kilo body weight x % burn surface
Electrolyte, 1.5 cc. x kilo body weight x % burn surface
Metabolic needs, 2000 cc. glucose in water

This expresses the fluid needs for the first 24 hours. One

half the total quantity is given in the first eight hours and the balance given uniformly over the next 16 hours The second 24 hours need may be estimated as one half the colloid and electrolyte requirements plus the 2000 cc. of glucose in water given uniformly over the second 24 hours After about two days, resorption of fluid from the burned areas begins and decreases the needs for such massive replacement therapy At the same time the burned surface begins to dry and the patient can be given oral fluids if able to take them Less severe burns can be treated with oral fluids entirely consisting of sodium chloride, 3 grams and soda bicarbonate, 1½ grams in one liter of water

Other supportive therapy given at the same time includes narcotics antibiotics and tetanus toxoid or tetanus antitoxin. A tracheotomy is utilized as indicated for respiratory tract burns.

Local Burn Care Local burn care is aimed at the prevention of infection and conversion of an open wound into a healed wound with preservation of function of the part. This includes cleansing the burned area, opening blisters and removing dead epithelium as soon as condition of the patient permits. Local wound care may be accomplished by the open or closed method of treatment. All burns can be treated by the closed method, that is by the application of fine mesh vasoline gauze covered by voluminous pressure dressings Not all wounds can be treated by the open method. There are disadvantages to both methods Not all parts of the body can be exposed adequately for treatment by exposure. In addition, the exposure method causes some discomfort for about 48 hours. The dressing method also has its disadvantages. Time is required to apply the large bulky dressings. These become moist and smell and must be

changed frequently Such changes are painful and often require anesthesia. The large universal one-piece dressing used by the Armed Forces is easily applied in the closed treatment of burns.

Application to Mass Casualties

Some index of severity of burns is necessary to serve as a guide for sorting large groups of burned patients. Using such a guide burn patients would be sorted into four groups (1) those who could give themselves self care, (2) moderate burns (3) severe burns, and (4) overwhelming.

Self-Care This group includes patients with less than 10 per cent third degree or less than 20 per cent second degree burns who are able to walk. Full thickness burns of the face, hands feet, genitalia, respiratory burns and fractures and soft tissue injury would place these patients in the moderate burn category It is expected that the self care group will make up the majority of burns in an atomic blast. Most burns are expected to be flash burns of the exposed surfaces. Such patients can be sent to a designated station where, with buddy care or care by untrained personnel, they can be treated early and be available for return to duty Since pain is a deterrent to exposure treatment, perhaps some simple dressing should be made available for self-application. The need for electrolyte replacement can be accomplished by furnishing the patient a plastic package containing sodium chloride 3 grams and soda bicarbonate 1½ grams, which can be made up to 1000 cc. of solution to be taken orally In addition, a supply of oral antibiotics for seven to ten days with instructions for taking should be supplied. In this manner the major group of minor burns can be cared for temporarily It is hoped that by the

time infection develops in five to seven days, medical care may be available to this group

Moderate Burns In this group will be placed those with 10 to 20 per cent third degree burns or twice that area of second degree burns Additional injuries as noted in the self-care group would place these burns in the severe group The self-care patients placed in this group because they were non-ambulatory could still care for themselves to a great extent. Others in this group with burns in the 20 per cent range will require some intra venous colloid and electrolyte replacement but while awaiting evacuation can be started on oral solutions of electrolytes, oral antibiotics and narcotics as indicated. This group will have a second priority for evacuation to a hospital or burn center

Severe Burns Into this group will be placed those with 20 to 45 per cent third degree burns These patients require aggressive treatment and depend almost entirely on intravenous replacement of colloids and electrolytes Such fluids should be begun as soon as possible. Anti biotics as penicillin and streptomycin can be added to the intravenous fluids Ideally these patients should be cleansed in 24 to 48 hours Such burns withstand evacua tion fairly well within the first five to seven hours. After that, if they respond favorably they may be transported in 48 to 72 hours. Such patients can be dressed with the large universal burn dressing for evacuation This group receives first priority for evacuation to a hospital or burn center Additional severe trauma and severe respiratory burns in individuals with up to 45 per cent third degree burn will place those individuals in the expectant group

Overwhelming Burns Into this group would be placed those with over 45 per cent third degree burns and those with less severe burns but with other severe complicat

ing injuries. Fatalities in this group are high even under ideal conditions. Most of those who do not die of shock in the early post burn period will die of their infection at a later date. Lack of trained personnel, equipment and supplies will require that burns of this category be given analgesics and set aside in hopes that supplies will become available to them, should they survive. Patients in this expectant care group will receive the lowest priority for evacuation.

Care At The Evacuation Hospital

Here priority for care will be given to those with the 20 to 45 per cent burns, with those with 10 to 20 per cent burns receiving second priority for care. Such care will have to be by nurses dentists, technicians and at tendants under the supervision of a physician. Treat ment will be supportive primarily with local burn care secondarily Oral fluid replacement will be utilized whenever possible but lack of catheters will not permit hourly urinary output observation. A fluid calculator such as devised at the Surigcal Research Unit, Brook Army Medical Center would be extremely valuable in estimating fluid needs. Those patients who have not had tetanus *toxoid booster or tetanus antitoxin should* receive it here.

As the patient receives supportive care, attention will be given to the local burn. Probably only minimal debridement will be required. Treatment will have to be by the open method. After discontinuing intravenous medication, antibiotics can be continued orally Infections will be numerous in one to two weeks. By then it is hoped that trained personnel or burn centers may be available where patients can be moved for evacuation for skin grafting.

To cope with such a burn catastrophe, we must have an

organized system of planning for personnel and supplies We should be ready to study any burn disaster that might occur in order to profit by it and plan accordingly At the same time we must maintain a constant teaching program.

Blood and Blood Substitutes

As with most of the requirements for treating mass casualties, it is impossible to estimate the blood needs since the numbers and types of injuries are only a matter of guesswork. Estimates can be made from previous wars, disasters and from information available from previous use of the atomic bomb To calculate needs on data received from the Hiroshima bombing may be entirely fallacious because of the various types of bombs now produced and the conditions under which they might be used. We cannot anticipate needs from conventional warfare. During such warfare a steady stream of patients usually is received at a well-equipped hospital with an adequate staff of efficient, organized medical personnel. Transportation of blood and supplies usually is no problem. With the chaos created by an atomic detonation, the deluge of patients and possible disruption of transportation facilities the problem of procurement of blood is further complicated.

During World War II in North Africa the British used 0 18 units of whole blood per wounded in action. Later during the war in Europe the use of blood was increased to 0.5 unit per wounded in action This usage increased to a maximum of 0.9 unit per wounded in action during the Korean War Here the battle line was stable, the hospitals were well forward, ample medical personnel and blood were available and transportation was no problem The blood supply was such that it was some-

times available in forward aid stations The average patient with an abdominal injury in Korea received 1500 to 2000 cc. of blood preoperatively to average a total of 3000 to 3500 cc. of blood the first 24 hours after surgery Even with the availability of blood the mortality of one group with severe injuries, each receiving over 15 units of blood was 44 per cent. In some instances severely wounded patients are known to have received 40 to 50 pints of blood. Even so only 20 per cent of the wounded in action received blood. Later in the Korean conflict, only type O primarily low titer blood was used without crossmatching. It has been suggested that for planning purposes the use of blood in Korea might be considered a maximum usage and that for optimal planning purposes one might consider the availability of one unit per wounded in action. In atomic warfare where thousands of casualties are expected, obviously such amounts of blood cannot be made available, therefore, compromises will have to be made.

Approximately one man hour is required to draw type, tag and titer one unit of blood. This means that approximately 40 people working in shifts could draw and process 1000 pints of blood in 24 hours provided donors, equipment and a place to work were available. It has been estimated that in an emergency the 1500 blood banks in the United States could deliver 150 000 units of blood a day However with a partially disrupted transportation system and other priorities which may be required of the available transportation, it probably will be impossible to secure blood from distant points and plans should be made to process blood locally

If for planning purposes we assume that of the injured one third will be walking wounded, one third will have moderate injuries and one third seriously wounded,

then we can almost automatically eliminate the seriously wounded group Many of those will die before being retrieved and others will be such poor risks that salvage will be impossible. Many will fall into the category above requiring numerous pints of blood Neither blood in such quantities nor time will be available for surgery for such poor risk cases It is not expected that the walking wounded will need blood so this eliminates another one third of the injured Blood available should be used for the moderately injured group which will have a high priority for surgery The peak need for blood for this group should be within the first 72 hours after bombing.

To further narrow the needs for blood, it might be pointed out that in Korea where optimum use was made of blood only 20 per cent of the wounded in action received blood and these were obviously the most injured. Since the severely injured in need of large amounts of blood in an atomic disaster will be eliminated from care, this greatly reduces the need for blood. Those trauma cases having received mechanical and blast injury which are good and fair risk patients will receive priority for care and should have fewer requirements for blood. Most of these patients can be operated on utilizing plasma expanders. The patients with thermal injuries who will receive treatment, should have little need for blood early Most of their early colloid needs can be made up with plasma expanders. Those patients with irradiation injuries will have no requirement for blood for ten to fourteen days unless thrombocytopenia from bone marrow damage causes hemorrhage. If so, then fresh blood is needed, should be drawn in a plastic bag and should be given immediately before the platelets disintegrate.

Plasma Volume Expanders

Plasma volume expanders which may be considered for use in case of disaster include blood plasma, human serum albumin, gelatin, polyvinylpyrrolidone and dextran.

Plasma. Plasma, although a blood product and most like blood, is not a blood substitute. The use of dried pooled plasma during World War II resulted in spreading viral hepatitis It has been found that 5 to 15 per cent of the pooled plasma contains the hepatitis virus. In addition to that it is expensive. At this time it appears that months of shelf storage of plasma at room temperature is going to be effective in eliminating the hepatitis virus.

Serum Albumin. Serum albumin was used fairly widely in Korea. It is convenient to transport because of its small volume. As a hypertonic solution it is an effective plasma expander by increasing the intravascular volume at the exposure of dehydrating tissues. It is an effective ex pander hepatitis free, but the cost is prohibitive.

Polyvinylpyrrolidone. PVP is a synthetic produce of formalin and acetylene developed and used in Germany during World War II. It is an effective inexpensive ex pander but its fate is unknown. Some is known to be stored indefinitely in the reticulo-endothelial system, in the skin and liver It has been recommended that if it is to be used that the total quantity be limited to 1000 cc.

Gelatin Gelatin is produced by the hydrolysis of animal collagen. It is a protein and utilized by the body A problem exists with gelatin in that when the molecular weight is great enough for gelatin to be an effective plasma volume expander and remain in the circulation, the gel point increases so that the fluid cannot be given during cool weather Lowering the gel point results in a reduction of molecular size so the gelatin is lost from the circulation.

Dextran. Dextran is a polymerized carbohydrate developed in Sweden in 1944 As such it is partially metabolized by the body It is an effective plasma expander and is not too expensive. It is stable as a 6 per cent solution in saline. It was evaluated and used in Korea and has been used extensively since It requires no refrigeration and can be supplied in plastic bags It is being stockpiled for mass casualty care.

In Korea dextran was used in various ratios with blood according to the severity of the wounded patient. For the patient in whom the need for blood was conjectural, dextran alone was used. In the moderately severely wounded patient one unit of dextran was used to one or two units of blood until 2500 cc. of dextran was given. In the severely wounded patient one unit of dextran was used to three or four units of blood until a total of 3000 cc. of dextran was given. Patients treated with large amounts of dextran were observed to have hemoglobins as low as 6.5 grams and hematocrits as low as 20 but progressed satisfactorily More recently, large amounts of dextran have been blamed with causing some bleeding tendencies. It has been reported that 2000 cc. of dextran will give some increased bleeding tendencies in 20 per cent of the patients

It would appear that in an atomic disaster, any blood available will have to come from local sources Since only fair and good risk traumatic cases will have surgery, they should require very little blood and may be treated with plasma expanders. The same is true of the treatment of burns. It, therefore appears that while some blood may be required within the first 72 hours for some surgical cases, most of these can be sustained with plasma expanders and the major need for blood will come in ten to fourteen days for use in irradiation injuries.

Treatment of Fractures

Battle experience shows an incidence of fractures in about 40 per cent of casualties which is not surprising since some 60 per cent of wounds involve the extremities. About 66 per cent of these fractures involve long bones and from the nature of the wounds over 90 per cent of the fractures are of the open or compound type. The Nagasaki experience showed only an 11.5 per cent incidence of fracture because of lack of evacuation and rescue work before the fire. From this, it has been estimated that in a thermonuclear burst, we may see 15 to 20 per cent incidence of fractures, depending on the speed of rescue. Another factor is that individuals close enough to sustain major fractures may sustain other lethal wounds or irradiation which would lower the number of fractures to be treated.

First-aid for fracture cases is of extreme importance and has been stressed for many years. Still, however it is rare to receive a fracture patient from an accident scene, adequate first-aid having been given If as we believe, in a mass casualty situation, first aid will be the sole treatment for 24 to 48 hours first-aid assumes an even more important place. All individuals should know four measures which they can apply to themselves or to buddies. They are

1. Control of hemorrhage by use of pressure points, compression dressings and/or use of the tourniquet in unusual and desperate cases.
2. Application of dressings to aid in control of bleeding, to prevent further wound contamination and to assist with immobilization.
3. Splinting of fractures is urgently important in any case but especially so in mass casualty conditions

where wound care may be necessarily delayed. Improvisation from any available material must be taught widely

4 Completion of a partial amputation may convert a patient who cannot be moved into one who can be handled and transported If stump bleeding cannot be controlled by a compression dressing a low tourniquet may be needed even though this causes additional loss of stump length.

Ordinarily when the wound is debrided the fracture is treated at the same time deciding on methods of fixation and immobilization partially on the degree of contamination and comminution A wound sustained on a clean ship deck is much more favorable than a similar wound sustained in the mud of a rice paddy Most open fractures incurred under battle conditions are best treated by the most conservative means possible, reserving more heroic methods for a later date as required. With mass casualties, it is even more necessary to do the simplest possible procedure so that debridement and plaster cast immobilization will be most often appropriate Such casts always must be split completely to allow for the moderate to severe degree of tissue swelling which always develops Failure to bivalve casts will cost lives and limbs. The principle of traction will have to be abandoned in mass casualty work because of the difficulty in attaining it, the constant care it requires the immobilization and non transportability of the patient from the traction apparatus and the complications often missed during evacuation.

The general condition of the patient is of prime importance, local wounds and fractures being cared for only when the general status warrants. Fractures themselves have a low priority for treatment if hemorrhage is no problem and once debridement has been accomplished.

Associated vascular injury takes early precedence in normal times but in a chaotic condition, vessel ligation or even amputation will be done rather than vessel repair Partly this is because of the press of time and partly it is due to the fact that patients probably will be available for treatment after too long a time has elapsed to make vascular repair feasible. Development of anaerobic myositis calls for early treatment at least by debridement and possibly by amputation. Many fractures will be complicated by soft tissue burns which take precedence. Ir radiation burns may be seen with some degree of frequency and here, it must be noted that early care is necessary or else we should wait to see the result of the irradiation. Operative procedures during the stage of leucopenia are poorly tolerated.

When amputations are done, it is essential that the guillotine type be employed and the soft tissues left open. Only in this way can we conserve lives and limbs. Wound infection will be almost routine and length of stump will be a minor consideration as compared to saving of life.

Finally, it is to be emphasized that trained orthopedists will not be available to assume responsibility for all fracture cases Fractures will be managed in conjuction with wound debridement, possibly by very unskilled persons under supervision. This further points up the necessity for broad training in methods of splinting and fixation which will not make the patient non-transportable and which can be employed by "casual" operators.

Prophylaxis Against Wound Infections and Utilization of Antibiotics in Mass Casualties

Statement of the Problem

In the event of mass disaster, casualties surviving the initial injury and the ensuing hemorrhage and shock will

face the added danger of wound infection with its potentially serious consequences. The unwarranted belief that wound infection no longer is a serious threat because of the battery of antibiotics available and the untenable conclusion that in the event that good surgery and debridement are not possible, satisfactory results may be attained with the antibiotic panaceas, must be combatted vigorously by a reevaluation of the problem It is anticipated that the casualty group will be made up of flash and flame burns secondary missile injuries, tissue destruction, penetration of body cavities, and the other forms of injury with which we are familiar The special problem arises from the overwhelmingly large volume of expected casualties as compared to the available skilled personnel, supplies, and time. Actually, then, what we are searching for is not a substitute for surgery but rather a suitable means of extending the golden period of six or eight hours beyond which we expect greater mortality and morbidity Those of us who had the experience of comparing the wounds from World War II and the wounds from Korea know of the latter's much lesser incidence of significant infection, the almost negligible secondary osteomyelitis and the greater opportunity for delayed closure which obviated much skin grafting and plastic reconstruction What we need now is a regimen which will allow us to attain acceptable results even if surgery is unavoidably delayed for hours or even days. First, let use examine the factors concerned in development of wound infection in order better to understand the problem which faces us.

Factors Concerned in Development of Wound Infection

Many times we confuse wound contamination with wound infection, an entirely different matter Wound contamination is universal even in the most aseptic circum-

stances, and yet the incidence of wound infection in hospital cases is not over 2 per cent. Contrast this with the statement that the surgeon s gloves become perforated in at least 25 per cent of cases All open wounds are subject to primary and secondary contamination with bacteria. Primary contamination occurs at the time of wounding from adjacent skin and clothing as well as hollow viscera perforation or foreign bodies such as dirt and missiles. These organisms primarily are the anaerobic spore-bear ing bacilli of gas gangrene and tetanus, pyogenic cocci and the coliform bacilli. Secondary or added contamina tion occurs at the time of or following local therapy, usually originating from the air or respiratory tracts and hands of those attending the wounded. Obviously there is a dosage factor here and the larger the wound, the longer the time of its exposure or the greater the bacterial concentration of the contaminant, the greater the likelihood that wound infection may supervene The organisms most frequently seen in this group are the hemolytic streptococcus, the various staphylococci and the Proteus and Pseudomonas species Two points need emphasis at this time. First, let us realize that the surgeon is not expect ing to sterilize his hands by scrubbing before operation but is merely attempting to cut down this dosage factor in case the gloves are perforated. Masks are worn only to filter out a percentage of respiratory contaminants. This indicates that expeditious surgery is less apt to be followed by wound complications than dilatory surgery When operating room technique is checked periodically by hand cultures after scrubbing, we do not expect to see sterile cultures but rather a low colony count. The other important point relates to the distinction between a posi tive wound culture and a wound infection. For example, Manson at the University of Minnesota found that cul-

ures from indolent leg ulcers yielded a 30 per cent in idence of the causative organisms of gas gangrene, and one of us (WFB) showed that muscle cultures from the proximal stump in a series of thigh amputations for dia betic or arteriosclerotic gangrene showed a 10 per cent positive incidence of these same organisms Yet, in no case n this series was there clinical wound infection of any ort. The incidence of gas gangere in Korea was extremely ow and yet some non medical scientists confuse this with he fact that many wounds in Korea on culture showed he organisms capable of causing gas gangrene if given avorable circumstances Let us clearly differentiate between a positive wound culture for organisms and an established wound infection The sum of the wound contaminants is a complex and changing heterologous bacterial flora on the wound surfaces, and whether or not wound infection develops depends upon the number of virulence of the bacteria as compared to the magni tude of tissue damage, the local surgical care given the wound, the response of the host tissues and the supportive therapy employed to aid and abet it

The response of the host tissues to bacteria may be altered in a number of ways. For example, resistance to infection is decreased by prolonged shock and anuria, electrolyte and metabolic imbalances bone marrow suppression by ionizing irradiation and by hormonal factors such as chronic stress or the administration of adrenocorticotropic hormones. Host resistance to bacteria is increased by correcting hypovolemia and altered blood chemistry values mechanical removal of devitalized tissue, rest and immobilization antibiotic therapy and the presence of circulating antibodies either specific or non specific. Host response is influenced also by the body area involved In wounds of the bowel continually

escaping fecal bacteria are able to establish themselves with great rapidity so that acute peritonitis may be manifested clinically within a few hours after injury In wounds of the soft tissues, of all the organisms which may be introduced, only the hemolytic streptococci and the clostridia of gas gangrene, and to a lesser extent the pyogenic staphylococci, are capable of massively invading and destroying normal tissues, with impending bacteremia, septicemia and death. Gas gangrene or clostridial myonecrosis is a disease based on the presence of dead muscle tissue and it begins 24 to 96 hours after wounding when the clostridia have been able to establish themselves by secreting toxins and by killing adjacent muscle by a combination of toxic action and tissue ischemia caused by gas tension in the tissues In the absence of dead muscle, or said in another way in the absence of an anaerobic medium, the clostridia behave as harmless saprophytes and gradually disappear

An exception to this is in some cases of septic abortion where the clostridia enter the open venous channels when the endometrium is distributed. The organisms then cause rapid death from bacteremia, septicemia and hemolysis. Development of wound infection depends also on the enzymatic capabilities of the bacteria. The harmless saprophytes cannot secrete enzymes which allow tissue invasion and consequently they normally remain as surface contaminants. Some organisms secrete hyaluronidase which allows them to dissolve the basement substance of connective tissue thus allowing rapid penetration. Others secrete a fibrinolysin which allows them to dissolve and feed on blood clot. Still others secrete an enzyme capable of dissolving the desoxyribonucleic acid found in pus and exudates, while some rely on their toxins to kill tissue for their food supply These factors

explain the varying modes of spread and incubation periods, depending on enzymatic action. This enzymatic activity in wounds is curbed by wound debridement which removes the bulk of the contaminants, the blood clots, the dead muscle and the other factors which favor wound infection. It can be seen readily that antibiotics will affect only those bacteria which they can reach, that their effect depends on adequate dosage at the site of the wound, and that antibiotics will not influence the other factors mentioned.

Dangers Inherent in Routine Antibiotic Prophylaxis

The antibiotics have not been an unmixed blessing and indeed some of their dangers, although discussed as theoretically possible for years, are only now beginning to be appreciated in actuality. Careless surgeons seized upon the antibiotics as a crutch and as an ever ready excuse in case poor technique should allow wound infection to develop. The ineffectuality of the antibiotic or poor resistance of the patient always can be blamed. This sounds faintly reminiscent of the ancient philosophy that if the doctor has done his work, any failure in result is surely the fault of the patient. Multiple instances are seen where it is forgotten that antibiotics are supposed to combat bacteria and these agents are given for mechanical or chemical diseases or for conditions caused by a virus. Many cases are seen where antibiotics are prescribed for a few days with the thought that if the patient does not improve a physical examination can be made at a later date. Recently a skin case was seen in which instance an antibiotic was prescribed with the statement that if there was no improvement in a few days an attempt would be made to label the condition with a Latin name descriptive of its appearance. These

are distinct dangers to the intelligence of the doctor and the health of the patient. Such unscientific therapy is all too frequent. The development of drug resistant strains of bacteria has been stressed for many years but only recently has this problem achieved real proportions. In various cities about the country, severe and lethal infections are being seen, caused by bacteria resistant to all known antibiotics This has been truly alarming in some instances. Also after the usual pathogenic bacteria have been killed, the super infections sometimes come into the picture. Here, since all normal bacterial balance has been removed, severe staphylococcal enteritis may develop or septicemia by organisms not normally pathogenic may supervene, or the various fungi may wildly overgrow their host. It is well known that we have learned to carry the burn cases through the stage of hypovolemia and electrolyte imbalance but now they are lost through septicemia by organisms formerly sa prophytes. We have postponed death and changed its cause but still lose nearly the same proportion of burns, depending upon extent and severity It must be remembered also that most antibiotics are bacteriostatic rather than bacteriocidal, and we now see too many instances where antibiotics are given after a simple appendectomy and the patient leaves the hospital follow ing a smooth course only to return shortly with a full blown wound infection or pelvic abscess previously masked and held in abeyance by the prophylactic antibiotics. This again is poor scientific surgery Finally we have needlessly sensitized approximately 5 per cent of the country's population to the common antibiotics so that when they are really needed the patient runs the not inconsiderable risk of a severe urticarial reaction or possibly a fatal anaphylactic reaction. The popular

habit of giving a few shots of penicillin for every cold or sore throat is a pernicious one but one that probably will continue by popular demand It seems elementary to suggest that antibiotics be given only for diseases caused by bacteria sensitive to the antibiotic chosen and that their prophylactic use be restricted to causes where there is real value to be obtained either as a preoperative preparation or as a 48- to 72-hour coverage postoperatively in cases well selected for potential benefit. Having laid the groundword in this preliminary discussion what is the probable place of antibiotics in the event of mass casualties?

Suggested Regimen in Event of Mass Casualties

First, let us review briefly the available clinically effectual antibiotics and we can quickly dispose of bacitracin, polymyxin and neomycin as being special purpose drugs of limited application Penicillin with its special derivatives, still remains the most versatile and generally useful of the group The modified derivatives include the aqueous potassium salt of penicillin G, penicillin V designed for improved absorption by mouth, and procaine penicillin G used for slower absorption from intramuscularly administered depots. The other antibiotics of wide use are streptomycin, erythromycin, chloramphenicol and tetracycline with its chloro-derivative, aureomycin, and its oxy-salt, terramycin Each of these drugs is characterized by a spectrum of effectivity for the various micro-organisms. The hemolytic streptococci and the pathogenic clostridia inhabiting wounds are highly and uniformly susceptible to several antibiotics except streptomycin, polymyxin and neomycin On the other hand, in spite of the growing list of clinically useful antibiotics there are still some species or strains of bacteria that are

resistant to almost all of the available drugs in tissue as well as in the laboratory This group includes some strains of staphylococci, proteus and other gramnegative bacilli, the organisms commonly associated with secondary or hospital infection. Also, most viruses and fungi are antibiotic resistant.

The problem of which antibiotic to choose is not as simple as it might seem at first glance. It is not merely a matter of a test-tube decision as to which antibiotic affects what bacteria, because clinical effectivity of antibiotics on susceptible bacteria is greatly modified by the biochemical environment of the tissues in which the micro-organisms are entrenched. Antibiotics exert their greatest effect in combating invasive infections of architecturally normal tissues by bacteria susceptible to their action. Hemolytic streptococcal and staphylococcal cellulitis and their rapid response to antibiotic therapy are examples Conversely, antibiotics may be totally *ineffectual against the same bacteria in the special* biochemical environment of a wound or an abscess. Inability to establish adequate and continuous contact between drug and bacteria, the limitation of phagocytosis as an agent of microbial destruction, and the change in Ph of the local area, all are contributory factors Therefore, the limitations of antibiotics include ineffectiveness against suppuration in necrotic tissue, reduced effectivity of streptomycin in an acid environment, the neutralization of penicillin by penicillinase-producing staphylococci *and gram negative bacilli, and ineffectivity* against bacterial toxins such as those of gas gangrene, tetanus and diphtheria. This again emphasizes the oft repeated statement that antibiotic therapy is no substitute for surgical intervention to drain and surgically cleanse the wound of acid products, blood clots dead tissue, and

bacterial colonies Thus we may summarize the requirements for successful antibiotic therapy as

1 Actively proliferating bacteria susceptible to the action of the drug in a tissue environment favorable to the drug and for optimal participation of the host defenses.
2. Adequate and continuing contact between the drug and the locus of infection
3 Freedom from toxic effects of the drug itself

It would be highly desirable if we could settle on one antibiotic as the drug of choice for mass casualty use and it would be much simpler if we could advocate one easy route of administration but unfortunately, neither of these desiderata can yet be realized. Although topical antimicrobial therapy can be applied to open wounds the uncertainty of reaching any but the surface bacteria, together with the demonstrated adequacy of systemic therapy for most occasions, has caused topical use to be nearly abandoned and has made parenteral therapy the usually accepted method of administration

The route of administration of chemotherapeutic agents is influenced by the nature of the drug and its behavior and fate in the body

(1) Drugs such as streptomycin, polymyxin, neomycin and bacitracin are not absorbed into the systemic circulation after oral administration, and when indicated, must be administered intramuscularly

(2) The oral route of administration may be contraindicated in patients with severe orofacial trauma, unconsciousness, gastrointestinal trauma or shock (wherein absorption is delayed and unreliable) For patients in shock, intravenous antibiotic therapy is the only effective means of aminlistration.

(3) Once the antibiotic has gained entrance into the

bloodstream, distribution is widespread in the body, but this is by no means the rule. The important exceptions are the central nervous system, pleural cavity major joints, and eye. For the central nervous system, chloramphenicol administered systemically affords the most effective tissue levels, followed by the tetracycline antibiotics and large doses of penicillin given intramuscularly or intravenously For impending infections of the pleural cavity and the major joints, systemically administered penicillin is often inadequate, and this inadequacy may be circumvented by supplemental local instillations of the antibiotic to provide effective levels of the drug. None of the antibiotics reach the internal compartments of the eye from the bloodstream in therapeutic concentrations.

Dangers of antibiotic therapy have been alluded to briefly including the 5 per cent incidence of sensitization to penicillin and streptomycin. Oral tetracycline therapy may induce gastrointestinal disturbances or staphylococcal enteritis mild to fatal. The incidence and severity seem related to the total daily dosage and the duration of administration. Chloramphenicol in this regard is safer but, experimentally causes leucopenia. The effect of chloramphenicol in mass casualties already showing leucopenia from ionizing irradiation has not been determined but it seems wisest to reserve chloramphenicol for cases of central nervous system trauma in treatment rather than prophylaxis Parenteral administration of the tetracyclines often causes annoying thrombophlebitis or prolonged discomfort around the intramuscular site. Parenteral administration of bacitracin, neomycin and polymyxin may induce nephrotoxic or neurological changes and, therefore their use is not advised as a routine prophylaxis By this process of elimination, then,

we are left with penicillin and its derivatives for use intramuscularly, intravenously or by mouth, streptomycin for use intramuscularly or intravenously, and the tetracyclines for use primarily by mouth. This essentially was the situation in Korea except that the tetracyclines were not widely available then This armamentarium seems to be quite satisfactory from the sandpoint of effectivity, availability, stockpiling, and ease of administration.

The avoidance of infection in patients with wounds of trauma is the chief problem after the patient has been resuscitated and is free of shock. If the dead tissue could be excised before local contamination becomes infection, the problem would be solved since the open wound could be converted into a closed wound. This ideal, however, is unlikely in any situation of mass disaster It will be necessary, therefore, to call upon every preventive measure at our disposal and several practical steps should be taken.

(1) Resuscitative and supportive treatment at the earliest possible moment is of primary and lifesaving importance.

(2) The value of local and total body rest must be recognized and employed within the limitations of the situation, both before and after debridement.

(3) All persons should be indoctrinated with the realization that the major threat to the large open wound is secondary infection. Whenever practical, measures such as masking and avoidance of manipulating the dressings or the wound with the bare hands should be taken to protect against secondary contamination since the nasopharynx and hands are the principal reservoirs for hemolytic streptococci and staphylococci. As regards thermal wounds it should be stressed that a dry burn wound ex

posed to clean air and daylight has a high degree of resistance to airborne infection For this reason, these lesions are better left alone rather than covered with greases, or antiseptic ointments, or inadequate dressings. It must be admitted, however that the widespread knowledge that minor burns feel better after a grease is applied will likely mean that such therapy will be used by popular demand.

All other penetrating wounds should be covered with a sterile dressing If none is available, a clean, freshly laundered towel, sheet, or handkerchief is justifiable. The dressing should not be removed until facilities are available for aseptic precautions during exposure of the wound.

(4) Every person, civilian and military should be immunized against tetanus which threatens following any open injury, missile or thermal. In the event of injury all casualties with extensive burns and particularly those with open wounds, should receive a booster dose of tetanus toxoid hypodermically This should be repeated at intervals of seven days in the presence of active clinical infection until three injections have been given. The non immunized casualty should be so protected at or shortly after injury The prolonged incubation period for clinical tetanus and the threat of hypersensitivity reaction to antitoxic serum favor the modern trend to reliance on tetanus toxoid series for active immunization in lieu of temporary passive immunization with horse serum antitoxin. On the other hand, gas gangrene toxoids are still in the development stage. There is no good evidence that gas gangrene antitoxin has any merit prophylactically or therapeutically

(5) Priority for treatment should follow established surgical principles. Decompression by drainage of skin

and fascia for superficial wounds of soft tissue should be adequate. Formal debridement is necessary for the more complex injuries involving muscle and bone and should be accomplished as soon as circumstances permit Care must be exercised in teaching that incision and drainage will suffice in emergency situations where debridement is not possible. Tissue tension may be con trolling hemorrhage from an injured large vessel and simple incision and drainage may allow fatal hemorrhage

(6) Antimicrobial therapy should be given to aid and abet the host defenses This step is taken on the basis of effectiveness demonstrated in laboratory animals against experimentally induced pyogenic and clostridial infections of extremities and against bacterial peritonitis Whereas factual data as to the value of chemoprophylaxis in man are meager the information available supports the wisdom of this practice in the face of the potential dangers of toxic reactions, bacterial resistance, and super infections inherent in antibiotic usage Antibiotics should be started promptly for all major wounded and discontinued or modified unless special indications are present at the end of three or four days.

The sulfonamides still are effective against hemolytic streptococcal organisms. Concern over crystalluria, hem atologic disorders, and other side-effects now are lessened with the availability of newer and improved sulfa drugs Primary use of sulfonamides for prophylaxis of infection in thermal injuries would spare antibiotics for serious established infections and tend to curb the emergence of drug resistant infections in large wards full of patients with burns and other open wounds

Oral administration when feasible and low dosage when it is not will minimize the problems and confus

ions of chemoprophylaxis. Three dosage schemes are suggested, one for the lightly injured, one for the moderately injured, and one for the severely injured.

For lightly injured adults who can take oral medication, penicillin G is preferable, given either as buffered penicillin potassium or sodium G, 500 milligrams every eight hours, or as penicillin V 250 milligrams every eight hours One of the *tetracyclines* may be *substituted for* persons known to be hypersensitive to penicillin the oral dosage recommended is 500 milligrams initially followed by 250 milligrams four times daily Except for prophylaxis against infection in penetrating head injuries chloramphenicol should be reserved for the definitive treatment of antibiotic-resistant staphylococcal and gram-negative bacillary infections. The dosage scheme is the same as for the tetracyclines It is further recommended that erythromycin also be reserved for the treatment of emergent staphylococcal resistant infections that do not respond to other agents.

For those unable to take oral medication or who have sustained injuries of moderate severity aqueous procaine penicillin G 300 000 units fortified with aqueous penicillin G 300 000 units may be given intramuscularly at 24-hour intervals. In penetrating trauma to the thorax and major joints parenteral therapy is supplemented with local instillations of this antibiotic.

For patients in shock, or who have sustained penetrating abdominal wounds intravenous therapy is indicated. Penicillin aqueous G or a tetracycline may be given. For penicillin, the recommended dose is 1 000 000 units (600 milligrams) given by slow drip and repeated at eight hour intervals.

Streptomycin, 0.5 gram, may be given intramuscularly

every eight hours in addition or added to the intravenous solution For tetracyclines a schedule of 500 milligrams at eight or twelve-hour intervals may be employed Intramuscular or oral therapy is substituted when the patient s condition permits.

Prophylactic antibiotic therapy is interrupted at the end of three or four days If infection has not been con trolled by this time a reevaluation of treatment should be instituted.

For the pure thermal injury problem, several choices of chemotherapeutic agents are possible. In addition to antibiotics there are the sulfonamides, which are still good antihemolytic streptococcal agents For adults an oral dose of one gram every six hours may be used, with abundant fluids. For children the suggested dose is 60 milligrams per pound per day divided into four equal doses at six hour intervals The limitations of sulfona mide therapy are ineffectiveness against clostridia, sta phylococci and certain gram negative coliform bacilli.

(7) Wound suppuration which appears at a later date is caused by other bacteria and the antibiotic treatment of established infection should be based on results of bacteriologic studies of wound cultures with substitution of the antibiotic to which the organisms are found to be sensitive.

This scheme makes it possible to hold in reserve the other clinically useful antibiotics, among which are chloramphenicol, erythromycin, bacitracin, polymyxin neomycin and possibly the newer drugs now being evaluated. Intercurrent infections due to such oragnisms as staphylococci, Proteus and Pseudomonas bacilli must be an ticipated, but if certain antibiotics are held in reserve, such budgeting should provide chemotherapeutic cover for the majority of problems of wound infection.

Summary and Conclusions

1. All open wounds are contaminated, primarily by the the wounding agent or visceral perforation and secondarily by the air or persons attending the wound.
2. The principal classes of micro-organisms of open wounds are the clostridia of tetanus and gas gangrene, the hemolytic streptococci and staphylococci and the coliform bacilli.
3. Behavior of these bacteria in traumatized tissue is influenced by the number and virulence of the organisms, the magnitude of tissue devitalization, the response of the host, the supportive therapy employed to aid and abet it, and the local surgical care given the wound.
4. Secondary contamination and infection are minimized by early application of occlusive dressings, masking and gloving of attendants and immobilization. No amount of chemotheraphy parenteral or topical, will substitute for negligence in these regards.
5. The keystone of prophylaxis against infection is early and adequate wound surgery The antibiotics will not remove blood clots or dead tissue nor will they favorably influence infection in such a medium. The antibiotics have not replaced surgery but rather have emphasized its importance. Antibiotics are junior partners of adequate surgery and properly employed they help to protect against invasive potentially lethal infection. Only the hemolytic streptococci, the clostridia and to a lesser degree the staphylococci are primarily invasive and these are predominantly susceptible to penicillin and the tet racyclines Antibiotics prevent invasive infection

by prolonging the lag period, and restraining invasion of contiguous undamaged tissues during this time by allowing elaboration of the natural leucocytic and fibrinous barriers

6 Penicillin, the tetracyclines and to a lesser extent streptomycin therefore, are the mainstays for antibiotic prophylaxis against invasive infection Topical application is not efficient and is not recommended Parenteral administration is the best choice although circumstances may dictate the oral route in some situations Untoward reactions may occasionally be a factor but this calculated risk must be accepted and a scheme for the use of antibiotics in event of mass casualties has been formulated

7 Hemolytic streptococcal septicemia is rare since chemotherapy and tetanus is not a problem in the immunized patient, while gas gangrene has an incidence of less than one per cent in modern warfare. The major problem now is persisting wound suppuration which will undergo septic decomposition regardless of systemic or topical chemotherapy In acute localized infections antibiotics and surgery are interdependent, antibiotics protecting against spread of infection by surgical manipulation of inflamed tissues.

8. Late infections frequently are associated with bacteria resistant to antibiotics employed for prophylaxis and for this reason it is advocated that the special purpose antibiotics be reserved for instances where they are specifically efficacious

9 This discussion has been presented to give a general understanding of the problem and as if adequate time and supplies were available. Under chaotic and restricted conditions, this is one instance where

we will operate on a sliding scale depending on availabilities and capabilities.

Hormonal Response to Injury

Emotional reactions and even localized body wounds evoke a generalized and fundamental hormonal metabolic response spoken of as the alarm reaction. According to this hypothesis, rage, fear pain and hundreds of other situations drugs or stimuli are capable of stimulating the adrenal medulla, resulting in an outpouring of epinephrine which in turn causes the hyperglycemia, peripheral vasoconstriction and oliguria that have been recognized as sequelae of trauma. The stress reaction is compounded of physical fatigue, fear, various psychosomatic symptoms resulting from fear psychologic symptoms resulting from this somatization, as well as the psychic reaction to battle including all the elements of loneliness bodily discomfort, frustration, revulsion toward killing, et cetera. All such reactions cause over response of the autonomic nervous system and, consequently the manifestations include muscular tension which may progress to "freezing" anorexia or nausea and vomiting, diarrhea, faintness tremor excessive perspiration, vague abdominal distress, tachycardia and urinary frequency All of these states are known in varying degrees to students before a stiff examination, to some surgeons before a difficult operation and to others subjected to severe stress such as seen in mass disaster

Hormonal Response

Increased adrenocorticotropic hormone (ACTH) liberation into the bloodstream from the pituitary is stimulated by histamine, epinephrine, atropine, acetylcholine, cold, heat and hundreds of other agents or environmental

changes As the name implies, ACTH stimulates the adrenal cortex with results which will be shown shortly Administration of adrenalin causes a fall in Vitamin C and cholesterol content in the adrenal cortex this being a measure of its functional activity This complex mechanism is a continuous one operating at varying degrees according to the severity of stimuli and depending upon a host of stimuli, the limiting factor apparently being the blood level of adrenal cortical hormones because when a certain level is reached the anterior pituitary is temporarily inhibited from producing ACTH In trauma, when there is a sudden using up of the cortical hormones, there is peak stimulation of the pituitary, the adrenal cortex being able to respond only if not exhausted by continued overstimulation. This entire train of events can be set off experimentally by stimulation of an exposed sensory nerve, exposure to 4 degrees Centigrade temperature for one hour, simulated altitude of 20,000 feet, hemorrhage of two per cent of body weight, intravenous injection of killed Escherichia coli organisms or scalding at 70 degrees Centigrade for five seconds

Adrenal Cortical Hormones

Desoxycorticosterone acetate (DOCA) induces retention of sodium with consequent excretion of potassium Retention of sodium causes water to be held and this train of events explains why potassium must be replaced in some severe responses why sodium chloride should be administered cautiously in the first few days after trauma, and why oliguria is temporarily present. These changes ordinarily revert to normal within three days in patients who can take a general diet by mouth. Arbitrarily attempting to change these reactions before that time may be meddlesome

Cortisone promotes gluconeogenesis by which tissue protein is converted directly to glucose and glycogen with concomitant excretion of the excess and liberated nitrogen in the urine. This explains the glycosuria and hyperglycemia after injury and is the mechanism for the "traumatic diabetes" which formerly was a confusing development. Also, cortisone favors dissolution of the lymphoid elements of the blood with release of gamma globulin, antibodies, and similar substances concerned with immunity to bacterial infection. After a single trauma, the lymphocyte count rapidly falls returning gradually to normal in 48 hours. This offers a practical means of measuring the effect of trauma and the bodily response and because the eosinophil count is simple, this is used as the gauge. After injection of ACTH, the greatest eosinopenia results in from three to five hours so this fact gives a good criterion for judging adequacy of response to injury The 17 ketosteroids are associated with nitrogen retention and therefore are anabolic for protein while cortisone is catabolic. These hormones are very similar in chemical structure to sex hormones such as testosterone and to the pituitary growth hormones. This may explain the apparently beneficial effect of testosterone administration during convalescence to hasten healing and well-being.

Reasoning teleologically it seems that the purpose of the adrenomedullary-anterior pituitary-adrenocortical mechanism is to prepare the body to withstand trauma, making the body as self-sufficient as possible. The ability of muscle to contract anaerobically for a short time obviates the necessity for increased blood supply in effort, permits function even after decreased blood supply by injury and gives to a person an extra burst of speed and endurance which may be lifesaving The quick in-

crease of epinephrine raises the blood pressure for better cerebral function, causes vasocostriction to slow hemorrhage, promotes gluconeogenesis so that the organism can survive without food intake liberates antibodies to combat potential infection retains sodium and water which together with the oliguria spares thirst, and in every way prepares the organism to lie quietly mobilizing its forces for healing and recovery

In primitive times these mechanisms were important and lifesaving but now are less necessary because of early resuscitation and surgical treatment. In mass casualty situations where definitive medical treatment may be delayed for two or three days these hormonal responses again may become of vital importance in allowing the organism to cope with injury and maintain life.

Brain and Cord Injuries

In World War II there was a 28 per cent incidence of wounds to the head face and neck but with the displacement of people and objects during an explosion it is estimated that a thermonuclear weapon might cause an incidence of 37 per cent of such wounds However only 3 per cent of the wounded in World War II had brain penetration and in the Worchester tornado there was only a 5 per cent incidence of head injury Consequently it seems justifiable to assume that neurosurgical cases in mass disaster will make up a small group Furthermore the inevitable delay in rescue and evacuation of patients will dispose of the most serious cases. While even penetrating head injuries do well with delayed care unconscious patients do poorly Kingman s experience in Korea being that patients admitted to a forward surgical hospital in coma usually died. The remaining case load will be small and relatively simple

It seems to be agreed that delay does not apprec harm the penetrating brain injuries in the first 72 l and they probably will have to wait at least this in mass casualty situations. Antibiotics and nursing will be helpful if available. These head injury should be transported to a special treatment area be this small specialized case group lends itself well to by special teams at designated points Since uncons patients do so poorly they should be placed in th pectant group and should be kept out of evacu channels. Management consists essentially of pl the patient in the coma position because respirator ficulty is the most frequent problem either from vo or secretions or from relaxation of the jaw and to The patient should be placed on his side with one and knee flexed to give stability Repeated triage o unconscious group will permit salvage of those wh cover consciousness spontaneously Drugs for pain i are not needed and morphine in particular is t avoided because of its respiratory depressing and p lary constricting effects Patients who are consciou dazed but in 24 or 48 hours become progressively i comatose, probably have a developing hematoma w should be evacuated by operation if feasible. Such tients give a good salvage rate in comparison to pat who are unconscious initially because this means h cerebral hemorrhage which is apt to be fatal. l likely that epidural hemorrhages from fracture ac a vessel will cause such rapid increase in intracra pressure that this case group will spontaneously rem itself from consideration because of early death. Wo dressing is important in the brain injury group bec

desperate circumstances it may be better to save the hair which can be tied to itself in such a way to close the scalp wound if dressings are not available Partial at tempts at treatment should be avoided so that unless the wound can be debrided adequately and the dura closed, it is better to give expectant care only With brain herniation no halfway measures are worth the effort.

Spinal cord injuries occurred in World War II in only one per cent of casualties but they take up a terrific amount of man hours and equipment Ideal management still is controversial opinion veering from year to year as to whether routine laminectomy is advisable. It certainly is true that in most cases immediate cord damage has been sustained and decompressive laminectomy does little for neurological function. Immediate laminectomy is good wound treatment but has little effect on eventual function. In mass casualty situations it seems evident that early laminectomy will not be employed and indeed Comarr showed in 858 cord injuries that delay in operation actually improved the results Spinal cord injury cases should be moved on a flat surface and should not be lifted by shoulders and knees. When brought to a treatment area, these patients should be placed in the expectant group and should not be allowed to get into the chain of evacuation because the end results are too poor to justify expenditure of time and supplies.

Maxillo-Facial Injury

Partly because of the high degree of vascularity of the tissues injuries of the face and jaws lend themselves well to minimal debridement and primary closure Failure in primary closures are caused by several factors, among which are the following (1) too tight closure of

tissues without provision for drainage, (2) failure to close the mucosal surface of the wound, thus allowing continued wound contamination by saliva and tending toward orocutaneous fistula formation, (3) secondary hemorrhage, usually from infection, (4) inadequate immobilization, wound care or chemotherapy

In mass casualty care, there will be no opportunity for primary closure but fortunately these wounds can be treated in first-aid manner with functional success. Although many of these wounds have a terrifying appearance, simple repositioning of tissues does wonders in attaining hemostasis, maintaining an airway, immobilizing bone fragments and making the patient ambulatory if he can see. Swallowing may be the most serious problem Collapse of the mandibular arch with loss of the points of attachments of the protruder muscles of the tongue especially the genioglossus and secondary pharyngeal swelling, are the principal airway threats in maxillofacial casualties Application of a Barton type bandage often suffices to re-establish the airway but in some instances the tongue must be pulled forward. This can be accomplished by putting a safety-pin through the tip of the tongue with a string attached and anchored to some fixed point such as a belt or shirt button. A suture passed through the tongue may be used similarly A rubber tube through one nostril into the nasopharynx may be lifesaving Tracheotomy depends on availability of a special piece of apparatus which may not be at hand but it is alleged that adequate ventilation can be attained through a No 13 gauge needle stuck into the trachea. This certainly is a hazardous method to depend on but is simple and temporarily satisfactory Arrest of hemorrhage usually is not a problem with a suitable dressing but it is useless to attempt ligation of vessels unless there

is opportunity for debridement Otherwise exposure is too difficult and bleeding is encouraged Nothing more definitive than these first aid measures can be expected but they will give functional results leaving cosmetic considerations for the future Approximation of key tissue points will make later work simpler

Abdominal Wounds

In most of the injuries discussed thus far some compromise not only is possible but is attended with acceptable results In abdominal wounds there is no halfway point between laparotomy and conservative management so there are no compromises to be discussed As has been pointed out previously there is an appreciable salvage rate in conservative management and we need not apologize unduly Early deaths in abdominal injuries are from blood loss and with delay in rescue which will pertain in mass disaster such cases will not live to reach a treatment facility Light has shown experimentally that inexperienced persons can do a laparotomy under supervision in thirty minutes carrying out certain simple routine procedures primarily aimed at hemostasis In disaster situations these patients probably will not be rescued in time to make use of this finding Surgery for bowel injuries when done after the first 12 hours does not improve the survival rate takes time and supplies makes the patient non transportable and therefore is not advisable The high mortality in the first 12 hours coupled with the relatively slight improvement following operation confirms the justification of a policy of conservative regimen unless full scale adequate early laparotomy is possible Because of the bare possibility that definitive care may be possible the following discussion is given

Physical Examination of the Injured Abdomen

Presuming that the state of consciousness and the respiratory and circulatory status have been evaluated, the injured abdomen is inspected for obvious wounds. Sometimes a bruise on one side of the point of missile entry may indicate the direction taken. Again, points of entry and exit give some indication of possible injury With obvious wounds, operative exploration is mandatory and further physical examination is needed only to evaluate concomitant injuries In abdominal injuries without penetration or in low chest penetrations where abdominal viscera may have been damaged, additional physical examination is necessary, sometimes repeated over a period of time to evaluate progress. Palpation to evaluate rigidity and rebound tenderness, percussion to show tympany or abnormal dullness, auscultation for presence and quality of bowel sounds, and rectal examination to evaluate or elicit tenderness blood or pelvic mass all add important information. Occasionally, simulated trauma is seen or there may be marked psychic overlay in a bona fide case of abdominal trauma. Usually a disparity between symptoms and reactions as compared to condition of the patient will make it obvious that simulation or exaggeration is present and the examiner can govern himself accordingly

Ancillary Examinations and Tests

The patient with a pentrating abdominal wound needs an x ray flat film of the abdomen. This is primarily to identify and localize missile fragments but in closed injuries may be helpful also from the viewpoint of localizing distended loops free fluid and air or areas of density which may indicate such misadventures as rupture

of the spleen Examination of the urine for gross blood is necessary and the only other essential data are those relating to circulatory status as determined by blood pressure level, pulse rate and hematocrit determination In closed abdominal injuries seen in fixed installations, occasionally a blood or urinary amylase determination may be helpful in suspected pancreatic injuries

Triage and Priorities for Care

Rather than having to decide whether or not the patient has to be operated upon the usual decision is which patients need priority treatment and which need resuscitative care before operation In multiple wounds, those which hinder cardiorespiratory function such as chest, neck and maxillo-facial injuries, must be managed first. Abdominal wounds take next priority while injuries of the brain and cord, extensive soft tissue wounds, genitourinary wounds and injuries of the eye can wait their turn provided that hemorrhage is controlled. Some military surgeons feel that extensive buttock and sacral wounds take precedence over abdominal injuries to avoid turning the patient after abdominal exploration. It is difficult to generalize on this point since obviously the patient may bleed to death into the abdomen while the posterior wound is being debrided.

Among abdominal injuries themselves, the patient with first priority for operation is the recent injury with good general condition, little bleeding and no concomitant injuries Second priority is accorded patients with severe injury by large fragments and those in shock. Here, blood replacement is first and only after shock has been controlled is operation undertaken. The exception is the patient whose blood pressure does not respond to suitable replacement and if shock is not improved after two

units of blood, severe vessel damage and/or retroperitoneal hematoma must be suspected, and here operation immediately may be lifesaving. In third priority are those patients with a closed abdominal injury or a suspected abdominal perforation. These require observation, resuscitation and operation within six hours if the need develops. Patients with no priority for operation are the obviously fatally wounded, those in severe shock with advanced sepsis, those with multiple wounds, and patients seen first after 18 or 24 hours Obviously such decisions are not as easy as they have been made to sound here but these several guiding principles are correct, whether the situation be in regard to battle casualties or mass casualties from some other cause.

Early and Resuscitative Care

Prophylaxis against abdominal injury includes keeping the belt tight in order to present a smaller target and keeping the gastrointestinal tract relatively empty before combat. This is difficult because constipation is frequent. Another point, possibly of greater importance is to turn the back to a blast or detonation if there is sufficient warning, and still better to fall prone in order to give maximum protection to the abdomen. In the event abdominal injury is sustained, nothing should be taken by mouth and protruding viscera should not be replaced but should be covered and protected by a massive dressing. Such a dressing covers the wound to prevent additional external contamination, prevents further evisceration and protects viscera already protruded. A narcotic for pain, preferably given intravenously and administration of blood or volume expander to treat shock should come early in the resuscitative care. Antibiotic administration should be started as early as possible, proper

records to show what has been done should be prepared and should be evacuated with the patient as early as possible so that abdominal operation can be accomplished within six hours if at all feasible. First aid and resuscitation overlap and *cannot be separated since all therapeutic* measures are continuous from injury to postoperative recovery Before evacuation, vigorous abdominal wall bleeding should be controlled and the foot of the litter may be elevated to assist blood pressure and to promote the maintenance of an adequate dry airway Catheterization to detect gross blood and to check urinary output is important and all measures should be taken to attain cardiorespiratory stability This includes an occlusive dressing to a sucking chest wound aspiration of a pneumothorax and such procedures avoiding meddlesome *measures and those which will make the patient non* transportable. Evacuation for operation within six hours is important and it must be stressed that the patient should not be moved from litter to litter during evacuation

The Non Penetrating Injury

In military practice the non-penetrating or closed abdominal injury is rare but is much more common in civilian practice as a result of falls and auto accidents. Special points in diagnosis and management have been stressed elsewhere under pertinent subheadings One additional factor needs to be discussed.

Blast Phenomena Pulmonary effects of blast in air usually are more important than those relating to the gastrointestinal tract, whereas blast in water is less apt to affect the lung. The critical distance is four times greater in water than in air and the severity of effect varies inversely with the square of the distance Symp-

toms depend somewhat on position so that in water, floating on the back is best, whereas on land, falling prone is preferable. Symptoms after blast in water include anesthesia of the legs, the urge to void and a sensation of water rushing into body orifices After 45 minutes there may be cramps and abdominal pain, followed in 24 hours by vomiting and diarrhea. After five days there may be soreness to rigidity and paralytic ileus Gangrene or rupture of viscera may occur Usually abdominal effects of blast are treated conservatively unless signs of gangrene or rupture supervene

The Thoraco-Abdominal Injury

Since World War II a change in concept has occurred so that no longer is the combined thoraco-abdominal approach advocated but rather two separate incisions are used. The thoracic wound is important from the standpoint of embarrassment of cardiorespiratory function or severe hemorrhage. In either of these instances, the thoracic procedure takes precedence. In other cases, the abdominal exploration is done first and in many cases a suitable chest exploration can be done through the diaphragm, avoiding a separate thoracic procedure. Perforation of the diaphragm requires complete abdominal exploration and this cannot be done adequately through a thoracotomy incision. Therefore, in thoraco-abdominal injuries some patients require thoracotomy first followed by laparotomy some require laparotomy followed by thoracotomy some require laparotomy only and probably it is safe to say that none require thoracotomy only

The Penetrating Abdominal Injury

Preparation. After resuscitation from the standpoint of airway and shock, operative exploration in cases of

abdominal penetration is indicated. Wide skin preparation in such a manner as to prevent additional peritoneal contamination, careful continuing attention to maintaining a blood pressure level above 90 millimeters Hg, and an inhalation anesthesia without multiple drugs or complicated apparatus are basic requirements

Incision and Closure The longitudinal midline incision is distinctly to be preferred because it allows speed in opening and closing, lends itself to extension if needed, provides adequate exposure and does not open the fascial planes of the abdominal wall to contamination. The missile wound should not be included in the incision but should be debrided separately Transverse and subcostal type incisions are excellent in elective surgery but have no place in casualty cases. Similarly, tight layer closure is accepted for elective cases but in trauma cases where there are mass casualties or where patients must be moved shortly after operation, or where there is peritoneal contamination, tight layer closure simply tends to cause infection, dehiscence and postoperative hernia tion. Through-and through closure with wire using rubber tube boots or tying over a gauze roll, with or without intervening skin sutures, is accepted as best meeting the requirements of surgery for abdominal trauma. Instances have been seen where the wires caused erosion-perforation of subjacent loops of distended bowel and for this reason the individual operator may prefer to close the peritoneum with continuous catgut suture and then place the wires through all layers except the peritoneum. Management of loss of abdominal wall substance may be a serious problem sometimes solved only by a massive dressing, while at other times relaxing incisions and local flaps may be effectual. Oc-

casionally tantalum mesh or other prosthetic substance may be needed later

Exploration. In exploring the abdomen, some routine procedure is best in order to avoid missing areas of injury First, points of hemorrhage should be located quickly and controlled by hemostats If the liver is the site of hemorrhage, gauze pack pressure will control it while the rest of the exploration is completed. If the spleen is the point of origin of bleeding, it should be grasped in the left hand, compressed to stop hemorrhage, and not released again until the pedicle has been multiply clamped and cut. The retroperitoneal area must be inspected for bleeding as evidenced by hematoma, and the site of injury *in the abdominal wall must not be neglected as a* possible source of hemorrhage. As the exploration progresses, if perforations in hollow viscera are encountered, they should be grasped quickly by Babcock or Allis type clamps to prevent further spillage and to facilitate locating them again after the exploration is completed. Only then should closure or resection be done, because otherwise, if perforations are closed as they are located, it may be found eventually that resection of a bowel segment is indicated after time has been wasted in multiple closures before the entire situation has been comprehended. Areas of perforation most often overlooked are the posterior wall of the stomach, the cardia of the stomach, the retroperitoneal colon and duodenum, and the mesenteric border of the bowel. The old saying that perforations always are present in twos is not entirely correct because perforation of a knuckle of bowel or a tear at the mesentery may give just one perforation. The whole small bowel should be brought out onto the abdominal wall so that exploration and visualization can be complete from

end to end and including the root of the mesentery No lesser exploration is entirely safe

Stomach In World War II the case fatality rate for stomach wounds was 41 per cent this being reduced to about 17 per cent in Korea One reason for this high mortality is the difficulty of locating perforations high on the cardia and into the lesser sac. Another factor is the high degree of chemical activity of gastric juice plus the continued contamination from fresh swallowed microorganisms Simple layer closure of perforations of the stomach is all that is required

Duodenum and Small Bowel In abdominal injuries, there is a 37 per cent incidence of small bowel damage and the case fatality rate of 30 per cent seen in World War II was reduced to 13 per cent in Korea. There is some variation in mortality rate as correlated with level of perforation in general those areas where there is the greatest chemical activity (duodenum and high jejunum), or greatest bacterial content (terminal ileum) having the highest rate In World War II duodenum injuries were fatal in 56 per cent of cases while in Korea this figure was 41 per cent. Small bowel perforations always are treated by primary closure or resection and anastomosis, never by exteriorization. This is because the relatively thick wall and relatively abundant blood supply make primary closure safe. Also exteriorization produces all the problems of fluid and electrolyte loss which are difficult in civilian practice and intolerable in military practice Resection should be done if the bowel is denuded of mesentery for 6 centimeters or less if viability is evidently impaired. Resection also is indicated if a short loop has sustained multiple perforations End-to-end anastomosis is preferred, by whatever suitable technique the operator favors Closure of individual

perforations is best done by an inverting stitch, although some advocate purse-string suture, clamp and tie technique, or covering by omentum

Colon and Rectum. There is a 35 per cent incidence of colon injury and the case fatality rate of 37 per cent for World War II was reduced to 15 in Korea. Wounds of the rectum carried a case fatality rate of 30 per cent in World War II as compared to 18 per cent in Korea. Here again, there is a correlation between level of injury and mortality rate depending on fluidity of bowel content and viability of bacteria. The established policy of exteriorization for colonic wounds or primary closure plus a proximal diverting colostomy still holds. This is because the colon wall is very thin and its blood supply is poor It therefore is very vulnerable to the concussive effect of missiles and primary closure fails in a high proportion of cases. All wounds of the rectum and many wounds of the perineum and buttocks require colostomy Usually if the wound is less than half the diameter of the bowel the damaged bowel may be brought out as a colostomy, but more extensive damage requires primary resection and exteriorization of both ends. Cecostomy is a notoriously poor operation and rarely is indicated in trauma cases because of the poor drainage effected and because it essentially establishes an ileostomy with all its disadvantages. Wounds proximal to the hepatic flexure may be primarily closed leaving a temporary tube cecostomy if the damage is not extensive. Severe wounds of the cecum and/or ascending colon are best treated by resection with end to-end anastomosis of ileum to transverse colon.

Colostomy Establishment and Closure A simple loop colostomy with incomplete bowel division is not satisfactory because it does not completely divert the fecal

stream Any technique which completely divides the bowel and separates the cut ends somewhat is suitable, provided that dressings are changed sufficiently frequently so that peristalsis in the distal loop will not draw feces into its lumen. The British type colostomy advocated in World War II, where the colostomy limbs are sutured together to form a spur, is no longer advised because it is needlessly complicated and makes subsequent closure difficult. The colostomy never should be placed in the main incision and never should be brought out through the original wound of entry or exit. When the time for closure of the colostomy has arrived an intraperitoneal type procedure always is advocated and if there is much scar tissue, excision with end to-end anastomosis is preferred.

Gallbladder and Bile Ducts Cholecystostomy has no place in treatment of trauma, and removal of the damaged gallbladder is advised. Biliary tract damage calls for T tube drainage and never for primary closure. In addition, a Penrose drain to the site of injury is indicated. Bile peritonitis need not be feared unless there is a continued leak of bile into the peritoneal cavity One insult by a gallbladder of bile is well tolerated.

Spleen Seven per cent of abdominal injuries include fracture of the spleen and in only 2.3 per cent of cases is this the sole injury In World War II the mortality from rupture of the spleen was 25 per cent and this was reduced to 15 per cent in Korea. In penetrating injuries of the abdomen, direct exploration makes the diagnosis but in non-penetrating trauma the diagnosis is more difficult. Evidence of internal hemorrhage as shown by lowered blood pressure and elevated pulse rate left shoulder strap pain and a positive abdominal x ray flat plate, tell the story The positive x ray findings are me-

dial displacement of the stomach air bubble, exclusion of gas shadows of bowel from the left upper quadrant with depression of the transverse colon and splenic flexure, plus diffuse haziness in the upper left quadrant with possibly some elevation of the left diaphragm The treatment is splenectomy as soon as the diagnosis is made. Continuing hemorrhage and the danger of secondary hemorrhage as the clot liquefies make temporizing too risky to be acceptable.

Liver In 27 per cent of abdominal injuries there will be liver damage and this carried a case fatality rate of 27 per cent in World War II, reduced to 15 per cent in Korea All devitalized liver tissue must be removed because autolyzed liver is highly toxic. Furthermore, blood in the peritoneal cavity must not be used for autotransfusion because of probably contamination. Liver wounds may cease bleeding spontaneously may bleed severely and may bleed secondarily Careful hemostasis is indicated by whatever means is effectual, from mattress sutures to fibrin foam, occasionally falling back on the crude method of gauze packing in unusual instances. A Penrose drain to the site of liver injury always is indicated and missiles should be removed if feasible.

Pancreas Pancreatic injury is accompanied by severe pain, profound collapse and often by an elevated blood and urinary amylase level. Case fatality rate in World War II was 58 per cent, being reduced to 22 per cent in Korea. Management is difficult but the aim is to stop hemorrhage and prevent leak. This may necessitate debridement, excision, inversion, re-implantation or combinations of these Blood calcium may be low because it is bound in the calcium soap formed in the areas of fat necrosis. Subsequent development of a pseudo-cyst of

the pancreas is a complication to be thought of in follow up examinations

Kidney Rarely does the urologist treat abdominal trauma, and most urinary tract injuries occur as part of abdominal wounding so that usually the general surgeon is implicated. The kidney is damaged in about 13 4 per cent of abdominal injuries In World War II, kidney injuries carried a 36.3 per cent mortality being reduced to 25 per cent in Korea. Rarely does kidney damage require nephrectomy because of bleeding Partial nephrectomy is indicated more frequently but usually a highly conservative policy is rewarding Extensive destruction of the kidney pelvis or the vessels at the pedicle is indication for nephrectomy

Bladder The bladder is perforated in about 5 per cent of abdominal injuries, and the mortality was 30 per cent in World War II being reduced to 9 per cent in Korea. The perforated bladder is treated by primary closure and insertion of a Foley type urethral catheter This is a change from former teaching, and now a suprapubic cystostomy is advocated only when a Foley catheter is not available. Simple urethral catheters are not trustworthy in patients who may have to be evacuated soon after operation.

Ureter Injuries to the ureter are so few and so infrequently recognized at the first operation that figures for incidence and mortality are not available. Ureteral damage most often is unrecognized and shows itself by urinary drainage from the incision later When recognized, the lesion should be dealt with by primary suture and a splinting ureteral catheter if damage is not too extensive, realizing that this procedure usually is not successful. The various ureteral transplants are not suitable emergency procedures and one often is faced with neph

rectomy if the other kidney is not damaged. Ligation of the ureter, leaving the kidney in place, is recommended only in desperate cases where the patient's condition or the press of time prevents more definitive care.

Retroperitoneal Hematoma. This has been alluded to several times but one or two comments remain. First, early placement of tapes around the aorta and vena cava, proximal and distal, may prevent rapid exsanguination as the dissection progresses. Next, it must be remembered that the adrenal glands are of extreme importance in the bodily reaction to trauma and hematoma around them may impede their function with fatal result. Finally tears in the vena cava or aorta are dealt with by primary suture repair by vessel graft, or by ligation as a last resort.

Foreign Bodies Whether or not to remove foreign bodies always poses a problem. Foreign bodies larger than a centimeter in diameter should be removed if they are accessible without undue damage to surrounding tissue For example, a small, smooth foreign body deep in liver substance should be left in place. Jagged foreign bodies are more dangerous than smooth ones and those which lie in proximity to vital structures into which they may erode should be removed. Non-metallic foreign bodies are more irritating and harbor bacteria so that their removal is desirable. Removal of foreign bodies always is secondary to the main consideration which is saving of life. Better to do a second operation on a live patient later than to complete the entire job at once on a patient who does not survive.

Burns of the Abdominal Viscera. Burns of the gastrointestinal tract may occur as a result of hot fragments penetrating the abdomen or due to burns on the eviscerated organs. Experience in this type of injury is scanty

but may become much more common Since the burn damage is progressive for a period of time rather than all damage being instantaneosly sustained, it seems wise to advocate exteriorization of burned loops of bowel without opening and protected by vaseline gauze Eventualities thus can be dealt with as necessity demands

Wounds of Entry and Exit Usually a large wound of entrance means high energy expenditure so that a small wound of exit may be expected Conversely, a high velocity missile which expends little energy on the wound of entrance is apt to make a large defect at its point of exit. From what has been said previously in the section of wound ballistics it is obvious that there may be wide destruction of muscle viability due to the temporary cavity phenomenon even if fascia is left relatively intact. This means that fascial planes must be opened generously enough to permit excision of all muscle tissue which does not exhibit free bleeding on incision Criteria of muscle contractility and tissue color are not as reliable as demonstration of adequate blood supply Due to the danger of evisceration the policy of leaving debrided wounds open for delayed closure does not apply to full thickness abdominal wounds Peritoneal closure with loose closure of the remaining layers is suitable, sometimes a drain in the wall being indicated.

Body armor still has a useful place in combat and this has been especially true in Korea where many wounds were from missiles of low velocity Even so it must be remembered that the armour may still transmit kinetic energy and thus itself may damage underlying tissue. This is obviated by placing an impact absorbing layer beneath the armor While body armor is hot and somewhat heavy, soldiers feel that it is "better to wipe sweat than blood."

Postoperative Regime and Complications Postoperatively, the abdominal injury patient should not be evacuated for five to seven days narcotics should be used sparingly but as needed, nasogastric suction should be continued until peristalsis has returned, intravenous fluids, blood and electrolytes should be administered according to the usual criteria of good surgery, antibiotic administration should be continued and proper records should be maintained. Postoperative complications include shock, secondary hemorrhage, wound infection, peritonitis, intestinal obstruction, wound dehiscence paralytic ileus abscess *localization*, *fistula* formation, and *incisional* hernia These things having been enumerated, will not be discussed further as to management.

Genitourinary Wounds

Wounds of the internal genitourinary organs ordinarily are dealt with at laparotomy for abdominal injury so if the policy is to treat abdominal injuries conservatively wounds of the kidney and ureter will be so managed also Blader injury is a little different in that some provision for external drainage is indicated. Catheters may not be available but first preference would be an indwelling Foley type urethral catheter next a supra pubic cystostomy and least desirable would be a supra pubic cystostomy without a tube. This would be a very messy procedure but a patient in face-down position could survive it. Damage to the external genitalia may cause severe bleeding controllable by dressings but urethral damage is a serious emergency Repeated needle aspiration of the bladder or suprapubic cystostomy is needed within six or eight hours if urinary extravasation is to be avoided. Passage of a urethral catheter probably will not be possible even if the catheter is available.

This type of injury is infrequent but poses a real problem.

Thoracic Wounds

Sucking wounds must be closed immediately if the patient is to be saved from a cardiorespiratory death. A compression dressing suffices nicely Fortunately lung injuries do not usually bleed severely and if they do, the patient will not live for rescue Most bleeding is chest wall in origin and the intercostal artery can exsanguinate a patient in a very few hours The pressure dressing for sucking wound can be used to compress the intercostal vessel as well. The other vessel which causes severe hemorrhage is the internal mammary which can bleed massively into the mediastinum or into the pleural cavity Compression will not suffice for this vessel which must be ligated if damaged. Air, blood and fluid are best removed by repeated needle aspiration and intercostal tubes are more dangerous than helpful Furthermore, they tend to make transportation of the patient much more difficult. In a mass disaster situation, thoracentesis is the mainstay of treatment for thoracic injuries

Management of Vascular Injuries

In Korea many young surgeons with little surgical experience and no previous battle casualty experience were able to suture injured blood vessels with a high degree of success. This is almost unfortunate as it caused an atypical situation to be thought of as a pattern for future casualty work. In a disaster with mass casualties, even laparotomy will take precedence over vascular suture, at least for peripheral vessels and in actuality the problem will take care of itself because most patients with vascular injury will be seen late enough that nothing but ligation can be considered anyway Loss of a

limb will be a minor price to pay for survival from a thermonuclear detonation or even from lesser disasters.

The Patient with Multiple Injuries

Even in normal times the patient with multiple injuries poses a difficult problem, largely artificial in nature, based on the anatomical landmarks and boundaries staked out by the various surgical specialties. The multiple injury patient represents a disaster in miniature requiring triage to decide the order of precedence with which *the injuries* are treated rather than the order in which patients are treated. Exactly the same thought processes are gone through in considering the one patient, thinking first of airway and blood volume before considering anything more definitive. Specialists tend to see their own field of interest out of perspective and it takes a strong team captain to keep treatment procedures moving and in proper sequence. Much time is unnecessarily wasted in diplomatic jockeying for position. This is analogous to the installation of a "seeing eye" door at the hospital entrance, requiring the services of representatives of nine labor unions to get the one job done. Trauma is no respector of dividing lines and the best interests of the patient take precedence. This is stressed at some length because too often planning type meetings bog down on the question of who will be the boss!

First-Aid, Transportation and Resuscitation

Discussion of the multiple injury patient is in reality a summary of what has been said except that one patient is involved instead of many. The doctor is not first to see the patient but rather he is preceded by lay men who may or may not have given first-aid care. The usual comments on stopping of hemorrhage, preservation

or establishment of an airway stopping sucking chest wounds and using care in moving the patient to prevent further injury, could be made but have been amply discussed previously If there is conflict of interest among the various injuries regarding position et cetera the most serious injury takes precedence For example stopping of hemorrhage takes precedence even if it means using a tourniquet which will devitalize the limb Resuscitative measures include more definitive stopping of blood loss, more adequate establishment of airway such as by tracheotomy if necessary starting of antibiotics, and starting of replacement of blood volume

Assessment of the Patient

Next comes triage or sorting as applied to the individ ual. This means a careful diagnosis as to what injuries are present and the status of each In normal times this assessment may be supported by laboratory and x ray studies but in a disaster situation, these may of necessity be omitted. The team captain then decides the order of precedence of the various injuries and begins treatment. He may call various consultants but this is not essential unless legal liability is a prime consideration. Anyone who undertakes to treat the multiple injury case should be competent enough to do most of the work if necessary and at least must know about the procedures in all involved fields In a disaster those who might be consultants probably will be busy as team captains them selves and thus the problem of who is boss will take care of itself

Definitive Treatment

In multiple injury cases shock is so frequent as to be almost universal and it must be considered constantly

It is too easy to become concerned with minutiae of treatment at the expense of the patient as a whole. An example of what should not happen is the case of a patient with a corn-shredder injury to the hand. The doctor worked all night identifying and suturing the various nerves and tendons. As he completed this beautiful anatomical triumph the patient drew his last gasping breath before dying of shock which had not been considered. This is an actual example. It has been stated previously that first things must come first. An example here is the patient who required repair of a false aneurysm and the adjacent peripheral nerve at the same time. The vascular surgeon wanted the arm in enough elbow extension to permit pulsation at the wrist and the neurosurgeon wanted extreme flexion at the elbow to take tension off the nerve repair Finally, it became necessary to arbitrate the matter by putting the arm in extension to the point where a pulse could be felt. This broke down the nerve repair which was re-sutured some weeks later after the artery had healed. Here, blood supply took precedence.

The team captain must be *time-conscious in multiple* injury cases because the scrubbing in of various consultants is terribly time-consuming. While it is true that time is not the fetish it once was, it still is true that a small quantity of anesthetic agent over a short time is easier on the liver than a longer procedure. There is a tendency to substitute operating by the calendar for operating by the clock.

Anesthesia and Analgesia for Mass Casualties

The field of anesthesiology has become such a maze of multiple agents and complicated gadgets that it is difficult to simplify our thoughts to fit an austere situa

tion with few agents and possibly no machinery It is possible that we may revert to intravenous morphine for short procedures and drop either for longer ones realiz ing the dangers involved Controversy still rages over the question of whether or not hypoxia is the cause of cardiac arrest but nonetheless it must be admitted that adequate ventilation through a constantly open airway is a basic requirement. This means that in addition to giving the anesthetic agent, the anesthetist must be able to give oxygen by a controlled positive pressure system, must have various means at hand to attain and maintain a patent airway and must be able to suck out the respira tory tree at suitable intervals Any compromise of these requirements will appreciably increase the risk.

Problems in anesthesia for mass casualties fall into three areas, the first of which is personnel It is per fectly obvious that there will not be a trained doctor or nurse anesthetist for each surgical team and we may be lucky to have one such person to supervise six or eight tables as we expect to do with our trained surgeons. All sorts of personnel saving devices must be used including wide reliance on regional or field block by local infiltra tion given either by the surgeon or the anesthetist if available and capable One skilled anesthetist can keep well ahead of the surgical team by giving blocks for extremity work. If apparatus is available the use of intra tracheal anesthesia actually is personnel saving because the trained person can insert the tube, start the case and then turn it over to a lesser trained person for mainten ance. This frees the senior for supervising work or in duction of additional patients. Basic training of all doctors in the elements of anesthesiology has been suggested but this probably will fail of accomplishment. Further more, it seems more logical to train paramedical persons

because much as doctor-anesthetists may dislike admitting it, we have for many years and usually do now rely on nurse anesthetists with success and confidence Questions of prestige must not be allowed to overshadow more important issues.

The problem of supplies, equipment, agents and techniques can be discussed at length but ultimately we will be forced to use what is at hand. Stockpiling of approved materials certainly is highly advisable but simple failure of transportation may nullify the entire effort. Kits containing such small but essential items as endotracheal tubes, laryngoscopes airways suction catheters syringes and needles must be available in every medical setup to be used over and over The real problem arises with expendable items such as morphine, atropine, curare drugs pressor drugs local anesthetics and intravenous fluids, all of which will be needed in stupendous volume.

The third main problem concerns the general principles to be employed and it does not seem practical to discuss various agents apparatus and techniques because anesthetists will have to use what is availalbe and perferably what they have been trained to use Many questions in this field are quite controversial, an example being whether pentothal curare does or does not cause increased case fatality in trauma cases As usual when good men choose up sides it can be assumed that neither group is entirely right and the final answer is not yet at hand We can be fairly safe in saying that spinal anesthesia has little, if any, place in surgery of trauma and it may be that the surgeon will have to direct an untrained person by periodically asking that more ether be poured on The only exception to this statement is that low spinal anesthesia or saddle block is useful and safe for surgery limited to the legs and perineum.

Irradiation Injury

Tissue damage by ionizing irradiation is a subject which has been allowed to assume undue importance in many discussions of mass casualty care Most disasters will not have this element and only with an atomic explosion does the matter even need enter the discussion Furthermore, the time intervals are such that seriously irradiated persons will die within the first two days having been easily recognized by progressive symptoms and less serious cases will not show need for treatment for as much as two weeks Thus there is no real irradiation problem during the time that we will be so busy with mechanical injuries and thermal burns Exeprimentally, it has been found that animals close enough to the burst to be injured by flying glass and such missiles received in addition lethal doses of whole body irradiation If this is the case in man our case load may require burial rather than treatment. We can dispose of immediate irradiation fairly easily but the subject of delayed irradiation injury is more difficult. Although the delayed injuries will not complicate the care of mass casualties because they will develop later after the emergency, fear of exposure may prevent early attempts at first aid and rescue. Most of the Sunday supplement type lurid discussions are given by people from academic and theoretical backrgounds without factual basis It would be very helpful if publicity could be denied to people who persist in speaking outside of their field of knowledge Good examples are the pronouncements regarding monsters to be born some 28 generations from now and the alleged high incidence of leukemia supposedly caused by radioactive fall-out.

If we consider only the irradiation injuries likely to be seen during the time mass casualties require care, we

see that there are three groups of cases which are quite readily distinguishable. The *cerebral form* of injury with a threshold dose of 2,000 R is characterized by convulsions tremor, ataxia, lethargy and death within two days. The *gastrointestinal form* of injury with a threshold dose of 500 R is characterized by dirrhea, fever disturbances of electrolyte balance and death within two weeks. The *hematopoietic form* of injury with a threshold dose of 100 R is characterized by leucopenia, purpura, hemorrhage and infection with death in two months. If we can estimate the dosage of acute whole body radiation received by a given patient, we can make the following prognostications with some assurance.

50 R will cause no casualties and no reduction in ability to work or fight.
100 R will result in 2 per cent casualties from nausea and vomiting for a short time. No evacuation is needed and these people can work or fight.
150 R will cause 25 per cent casualties within a few hours of which 50 per cent will need evacuation and will be ineffectual.
200 R will cause 50 per cent non-effectiveness and all such patients need evacuation.
300 R will cause 20 per cent deaths with the whole group being ineffective and needing evacuation.
450 R will result in a 50 per cent mortality rate.
650 R and over will give a 100 per cent mortality rate.

Divided in another way by clinical course, the following chart is derived.

	100 R	200 R	300 R	400 R	500 R	600 R	
Lethal				39%	94%	100%	Hospitalization Required
Grave			26%	58%	6%		
Serious		2%	68%	3%			
Moderate		64%	6%				Hospitalization Not Required
Light	2%	33%					
Trivial	98%	1%					

Utilizing the symptoms and the tempo of the illness, three arbitrary groups of cases emerge.

Group I Survival Improbable Vomiting will occur within a few hours of the bombing progressing with prostration, diarrhea anorexia, fever and early death A profound leucopenia develops within 48 hours and there is about 100 per cent fatality within a few days In normal times, heroic treatment may save a few of these individuals although the treatment is purely supportive and non specific. Measures include bed rest, parenteral alimentation, careful hygiene of mouth, teeth skin and perineum and prophylactic antibiotics as blood destruction continues. Transfusions of freshly drawn blood are indicated for their leucocytes and platelets In disaster situations these patients will be placed in the expectant group where they will die of shock from dehydration or overwhelming infection

Group II Survival Possible Vomiting will occur on the day of bombing but will subside within a matter of hours. This is followed by a latent period of from one to three weeks terminated by recrudescence of illness with some or all of the following purpura, epilation, oral or cutaneous lesions wound infection, wound breakdown and bloody diarrhea. Untreated the mortality rate will be high but intensive treatment will give good salvage. Elements of treatment are identical with Group I except that attention will not be demanded in the latent period. Infection is the major hazard and fresh blood transfusions are important. In disaster situations these patients will not require treatment for two or three weeks so it is hoped that some degree of stabilization will have been brought about before treatment becomes necessary

Group III Survival Probable No vomiting or other symptoms develop on the day of bombing and late symp-

toms if they develop will be similar to those in Group II Serial white blood cell counts may give the only indication of the injury and mortality will be low unless present in conjunction with burns mechanical injuries and infection. Prophylactic antibiotics do not seem indicated and these drugs should be used only in complicated injuries in conjunction with irradiation injury

Group Behavior in Mass Disaster

At first glance it may not be apparent why a discussion of group behavior fits into consideration of mass casualties but the point was made early in this book that we as medical men will accomplish little or nothing unless literally hundreds of people in others fields of work do their job and do it well. A more formal statement of this fundamental point is that the efficiency of the medical service rendered in a disaster situation is directly proportional to the prior understanding by medical personnel of the way in which non medical but ancillary problems are apt to be handled. The physical impact of disaster is important but more important to the recovery effort is the effect of disaster on the socio-cultural system. We take for granted such things as telephones, gasoline, electric power truck and rail transport, social and moral values passable streets and roads, policemen, ambulance drivers litter bearers ward attendants, cooks and the hundreds of other people and skills on which we depend daily In a disaster situation some or all of these may be disrupted, people may not be able to do their jobs for physical or mental reasons and while we are required to do our administrative and therapeutic tasks at an increased rate under adverse circumstances, we also may face difficulty because of the emotional reactions of those ancillary persons on whom our success depends. This

is why we must understand what to expect of people in a disaster and why we must be concerned with training and educating persons in the ancillary skills on which we depend

First, we may think of the time-sequence of events leading up to and following a disaster

1. *Normal State* What happens later on will be modified by kinship economic, political and religious systems class and caste climate topography and state of training of the population The state of training and discipline would appear to be extremely important and our ideal should be to have everyone so trained for specific action that function would automatically begin on the given signal. This is of course, completely impossible of attainment as long as people remain human but some effort must be made in this direction
2. *Threat and Alert Warning* The ideal would be for individuals to receive the warning in the pre-determined manner and immediately begin to prepare for evacuation, for reporting to duty station, for taking cover or for whatever has been taught in training or whatever instructions are given with the warning. Unfortunately many times the siren won t blow radios go dead or in some other way people fail to get the word. Not always is this a mechanical failure and in fact usually it is human failure. Some people just don t hear the alarm others dismiss it as being a test which they customarily ignore, some decide to run across town to gather up members of the family while others display the ultimate in childish response by clogging the switchboard with useless calls or by dashing off to the scene of activity to become one of a herd of spectators who either

endanger themselves or interfere with others. Training of the population is a partial answer but for the majority, rigid police control is a necessity

3 *Impact and Isolation* When the extraneous force strikes, this sets in motion the train of events beginning with injury and progressing through self and buddy help until outside aid arrives Most people seem to feel that a panic reaction is to be expected but the history of disasters does not bear this out. Just the opposite is usually the case with apathy purposeless movements wandering about, inappropriate action, and lack of comprehension of what is going on. Panic tends to follow entrapment and may develop in individuals who are separated from loved ones whose fate is unknown. During this period first aid and self help would be of great benefit if people could be so well trained as to begin purposeful functioning

4. *Rescue and Rehabilitation* At this time the effects of adequate training begin to pav dividends as bull dozers open roads, traffic and police control are established, communications and transportation are started, secondary hazards such as fires and live wires are controlled and finally ambulances or litter bearer rescue workers enter the area. It is at this time that training is important to prevent hurried evacuation of the wounded without first-aid, dang erous dashing about of speeding vehicles useless waste of supplies failure to carry out pre-determined courses of action or equallv reprehensibly the blind attempt to carry out an inflexible plan which no longer is applicable. It is at this time that authoritative figures must arise and assume control in these various fields of action.

This previous discussion covers the time-sequence but now let us look at the disaster from a space viewpoint.

1. *Total Impact* At the disaster center, facilities and individuals may be so disrupted that there is no coordinated effort and even little attempt at self help Aid must be brought in Each city should have two types of plan—one which envisions it as the target to which help must be sent and the other where it is the area from whence help must radiate to a damaged zone Here again, pre-planning is required and individuals in control must be ready to function.
2. *Fringe Impact* Minor damage in this area leaves people free to offer help to the total impact zone. However, the reaction of people is colored by emotional factors in strange ways. Instead of offering help, these people may feel that they must guard what they have for themselves or in one instance refugees from a polio epidemic in a big city were met by armed guards at smaller towns and were denied entrance or help Altruistic action seems to take place mostly if there is no real threat to the individual offering aid. This is not always true, of course.
3. *Filter Area* The undamaged peripheral zone is the source of the first rescuers but equally it is the origin of the first sight seers, curiosity seekers and potential looters. These people compete for road space with evacuees and rescue workers so that serious traffic problems may arise here
4. *Organized Aid* More distant areas tend to remain more calm, dispatching aid in various forms.

Group response to disaster may be analyzed in two main ways, we may speak of what will be seen in indi

viduals in the way of anxiety apathy and panic (epidemiological approach) or we may speak of what will happen to the functioning of some socio-economic area such as transportation system or communication network (structural approach) In either case, what will eventuate in the way of function is a combination of what mechanical damage has been done to the structural system plus what emotional and physical changes have taken place in the people manipulating the structural system. It seems apparent that a switchboard is no good if the operator is too apathetic to plug in the lines or if the repair man has severe burns of his hands.

Individuals tend to go through distinct stages of reaction to a disaster with marked variations in the speed with which progress is made First is the *Shock Stage* when the individual tends to be apathetic, stunned, dazed, wandering purposelessly acting inappropriately and even failing to recognize his own serious injuries. In the *Suggestible Stage* the individual can follow orders and will do routine tasks. There is concern over the welfare of others and gratitude for what has been done. The *Euphoric Stage* follows and the individual is very anxious to help others, wants to donate blood, engage in rescue work and will praise work of rescue and first aid personnel. Finally the *Rationalization Stage* is characterized by complaints against rescue and relief agencies concern over financial and domestic losses and excuses for personal behavior to put a good light on questionable actions. This stage is evident to investigators who try to get information at some time after a disaster.

Major determinants of behavior under disaster circumstances are intensity and duration of the traumatic agent, state of training, preparation and discipline of the population, efficiency of communication, availability of ac-

cepted leadership and existence of feelings of group unity Reduced to elements for planning there are five areas which must be under control if we are to be able to function medically

1 *Coordination with Non medical Agencies* As has been said several times and in different ways we cannot function unless we are coordinated with public utility plans, communications and transportation systems, police medical supply agencies and a host of other persons and facilities
2. *Authority* Any plan we make is not worth the paper it is written on unless there are designated and accepted authorities to assume control exercise leadership and make decisions
3. *Speed in Reduction of Time of Pickup* Expeditious careful rescue work as soon as possible is a terrific morale factor and depends entirely on a smoothly executed pre-planned operation. Our soldiers are so indoctrinated with this concept that when wounded they are apt to yell, "Litter bearer!" before they even hit the ground.
4 *Flexibility of Plan* Rigid plans are useless and too many casualty exercises assume sparing of facilities and utilities, or other conditions which are simple or unrealistic. Plans must not be tied to rigidly organized teams, specific buildings, or other inflexible elements. Improvisation is of extreme importance.
5 *Local Self-Sufficiency* It is all very well to hope for outside aid but plans should be made as if outside aid will be unable or unwilling to come. Let us act on the statement of Hippocrates that prayer indeed is good but while calling on the gods a man should himself lend a hand.

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